INTRODUCTION TO PSYCHOLOGY

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To

THE MEMORY OF

WILLIAM JAMES

THIS VOLUME

IS AFFECTIONATELY

DEDICATED

PREFACE

"NOT psychology, but to psychologize"[1] represents the educational objective toward which this book has been written. This fact accounts for certain characteristics as to method of presentation, selection and arrangement of content, direct address, and changes in style, all of which contribute toward action. It also accounts for the fact that the book is not a dictionary of psychological definitions or an encyclopedia of psychological facts.

John Hunter, the famous physician, once said, "Don't think; try," by which he really meant, "Think, but do not stop at thinking; test your thought by experiment." The experiments and exercises are designed to occupy about the same length of time in the preparation of a lesson as the study of the body of the text. No apparatus is required, but the instructor will occasionally find it advantageous to supply such things as paper and pins. It is essential that the exercises be performed with serious precision and thoroughness and that the record be made before reading the interpretative discussion which usually follows the directions. In accordance with available time and resources of the institution, demonstrations, class experiments, and further class exercises

[1] A paraphrase of *οὐ φιλοσοφία, ἀλλὰ φιλοσοφεῖν*, the Greek legend which may be translated, "not philosophy, but to philosophize."

without apparatus should be introduced by the instructor in such a way as to sustain the experimental attitude and point of view for those parts of the book for which facts are merely summarized. By this method, the student will not only read *about* psychological facts, but will *do* things psychological. To maintain this attitude of introspection and direct attack on the problem, the style of direct address is employed with great freedom. The good instructor will continue this in classroom discussion, at every point challenging the student to first-hand observation, discrimination, and thinking, instead of merely conducting the recitation about listed facts. The radical shift from light to heavy material — from the sustained argument or description at the student's level of achievement to a more or less massive summary of facts — is due to the use of the inductive method. The material is collected at the student's level of achievement and this is followed by a recital of facts to round out and furnish a setting for the exercises in the book and the instructor's demonstrations and experiments before the class. The frequent use of simple, direct statements of fact should foster precision, clarify thought, and point the discussion.

There is no general agreement among psychologists as to what should constitute a first year course in psychology. The selection of topics has been made on the basis of experience in the classroom, from the standpoint that the aim of the course is not to make technical psychologists, but to make an introduction to psychology function in the life of all students both in and after college. This accounts for the frequent references to

the beauty of mental life and the use that a given bit of knowledge may have in the direction of human energies, particularly toward mental health and education. The physiological part is thrown into the background and touched on but lightly, because a common mistake in the teaching of psychology is to waste the time for psychology in teaching anatomy and physiology; the essential facts about the nervous system are presented, largely through illustrations, in the Appendix.

The order of topics is not fixed. Some instructors may prefer to begin with the chapter on Attention; others may begin with the chapter on Reflexes; and there are even some reasons for beginning with the chapter on Dreams. For facilitating such freedom in arrangement of the courses, chapter topics are made fairly complete units. Let it be said once for all that for practically every topic that is taken up, it would be logical to say, "On this point authors differ; the situation is exceedingly rich and complicated; our knowledge in this field is very scant at the present time; and the author's view may often be wrong." Let the student read this statement into the text at every stage and treat the author's presentation essentially as a working hypothesis.

The author has drawn extracts freely from his *Elementary Experiments in Psychology* (Henry Holt & Company), *Psychology in Daily Life* (D. Appleton Company), and *Psychology of Musical Talent* (Silver, Burdett & Company) and, for this privilege, extends his hearty thanks to the publishers. Thanks are also due to the authors quoted in the text and to authors and publishers for the privilege of using certain conventional illustrations.

To the several psychologists and other friends who have kindly read parts of the text and given valuable criticisms, he expresses his very sincere appreciation.

C. E. S.

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CHAPTER I

INTRODUCTION

What is psychology? — Psychology is the science of mental life. That part of biology which deals with human and animal life falls into three fundamental sciences: anatomy or morphology, the science of structure; physiology, the science of function; and psychology, the science of experience and behavior of the organism. There is no sharp line of demarkation separating these three sciences; because in all animal life the anatomical, the physiological, and the psychological phenomena are intimately associated and mutually conditioned. In any adequate account of human and animal life from one of these points of view, it is necessary to take cognizance of the other two, and there is always an overlapping; but the primary task of psychology in this division of labor is to describe and explain mental life in terms of experience and behavior.

We recognize both pure and applied psychology. Pure psychology is the systematic description and explanation of the phenomena of experience and behavior in themselves; whereas applied psychology, or psycho-technology, treats of the practical application of psychological principles to life in any and all of its avenues of expression. All philosophy, art, pure and applied science,

literature, commerce, and the routine of daily life employ or deal with mental processes in some capacity; but they are not therefore psychology. The procedure is psychological only to the extent that we deal with these phenomena *as such*, whether pure or applied.

Psychology is a natural science since it regards its processes as observable phenomena in nature, amenable to natural laws; and, as it attempts to describe and explain experience and behavior of living beings, it is a biological science. The study is scientific to the extent that it is systematic and the conditions of observation are variable, repeatable, and recordable under control. Although no science ever attains this goal in full, psychology, like other sciences, makes gradual progress toward this ideal.

Psychology has generally been limited to the study of mental life in the narrow sense; and behavior has been considered only as mental behavior, or in so far as it has some relation to mental activity; but, as there is no sharp division between behavior which is conditioned upon mentality and that which is not so conditioned, the scope of psychology tends to extend so as to include human and animal behavior in general. For the sake of brevity, we shall use such terms as "mental life," "mental processes," "mental capacities," and "behavior" in this textbook in the broad sense so as to include also the behavior of man or animal which is not directly associated with mental activities wherever the connotation will make this legitimate. A sustained effort to distinguish and specify the two aspects would lead to intolerable repetition and cumbersomeness.

Branches of pure psychology. — In the division of labor, psychology, like other biological sciences, recognizes subdivisions both in pure and applied psychology, each representing a particular approach to the subject according as it is studied, for example, from the point of view of man or animal, adult life or development, the normal or the abnormal, the individual or the group. As now taught, psychology is presented in several fairly differentiated courses. Ordinarily there is one general introductory course furnishing a general survey from varied points of view, such as that represented by this text. Beyond this, specialized courses are offered.

A technical laboratory course in experimental psychology furnishes training in the fundamental principles of scientific procedure in observation, measurement, statistics, interpretation and formulation of the laws of mental phenomena. This course furnishes a fundamental technique which should be employed in all branches of psychology regarded as scientific or experimental.

Physiological psychology usually reviews the facts about the nervous system, as taught in neurology, for the purpose of tracing the physical basis of mental life and showing the relation between the mental and the neural.

Genetic psychology is divided into two parts: mental evolution, dealing with the development of mental life in the species, and mental development, dealing with the unfolding of mental life and the integration of behavior in the life of the individual. This includes psychology of infancy, of childhood, of adolescence, and of senescence. Within this field lies also the problem of the inheritance of mental traits.

Abnormal psychology deals with mental phenomena that are strange and irregular deviations from the normal but not strictly regarded as disease; such as hypnotism, mediumship, and alterations of personality.

Animal psychology presents a field of great interest in itself; but it is of special significance in that it throws light upon human life, particularly in the study of the simplest and the highest forms of animal behavior.

Social psychology treats of the social aspects of mental life and often blends into other subjects, such as anthropology, social origins, social ethics, social welfare, and eugenics. Sometimes race psychology, or the psychology of peoples, is differentiated from social psychology.

Individual psychology is perhaps the most conspicuous field of interest at the present time as it is the foundation for "human engineering" in all its forms of selection and guidance of individuals as well as for an intimate and accurate account of character or individuality of a person. It has recently gained great impetus through the development of so-called mental tests.

Statistical psychology is a basic requirement for mental measurement, particularly as employed in mental and physical testing and in psychology applied to education, commerce, sociology, and vital statistics.

Behaviorism is a purely objective study of human and animal life without reference to the testimony of consciousness.

These mere names for courses are more or less self-explanatory and may suffice to indicate roughly the principal points of view that the serious student of psychology must acquaint himself with, as each con-

tributes a distinct element to the conception of psychology as a whole.[1]

EXERCISE. — *Write and bring in one question under each of the above nine heads to illustrate what kind of questions you think are answered in each branch of psychology named.*[2]

Branches of applied psychology. — *Psychiatry*, as the science and art of the treatment of mental diseases, is the only fully specialized profession which may be regarded as applied psychology, although in many respects it has developed independently and has contributed much to normal psychology. But aside from psychiatry proper, there are many specialties in medicine in which expert knowledge of the human mind and behavior is fundamental; as in the care and treatment of children, and the mental treatment of all types of defectives and delinquents. Preventive medicine, public health education, and mental hygiene and sanitation are built largely upon psychological foundations.

[1] *Psychoanalysis* has come in from the medical side as a unique and new approach to the study of mental disorders, such as hysteria, morbid fear, aversions, and suppressed desires; but it also throws much light upon the nature of normal mental life. This is yet a polemic field in which we find great enthusiasms and antagonisms in contest.

[2] *To the Student.* — The following nine questions are illustrative. They are all taken from the same field; namely, the perception of color. It is, however, not necessary to choose them from one field; you should choose for each branch questions which are of most interest to you. Your list of questions will be a good index to your power of independent observation and thinking and, therefore, to your ability to study psychology.

Experimental — What are the laws of color contrast?
Physiological — What are the sense organs of color vision in the retina?
Genetic — What purposes does color vision serve?
Abnormal — What are the prevailing types of color-blindness?
Animal — Do any lower animals see any colors that we do not see?
Social — Why is red the flag of danger and terror?
Individual — How can we measure quantitatively an individual's sensitiveness to color?
Statistical — Do children show the same color preferences as primitive people?
Behavioristic — How fine distinctions in color can a peacock see?

Educational psychology presents numerous phases. Thus we have the psychology of the course of study, of the child, of the adolescent, of the learning process, of discipline, of particular types of training, and of special classes. The science and art of education is primarily applied psychology.

The psychology of business and industry appears in several large and distinct fields, such as the psychology of advertising, of salesmanship, of personnel, and of vocational selection and various types of efficiency activities.

Legal psychology appears in two groups of interest: first, the psychology of evidence or testimony and pleading; and second, the psychology of crime, delinquency, defective mentality, penology, dependency, correction, and special types of mental deviation.

Applied social psychology takes such forms as the psychology of social amelioration, eugenics, race betterment, child welfare, community welfare, recreation and amusement, and vocational and avocational guidance.

The psychology of art appears in the psychology of music, of graphic and plastic arts, and of literature, dealing in each case with the psychology of art principles, the psychology of the individual, and the psychology of training for the art.

The psychology of religion is applied mainly in the interpretation of religion and religious life, and in the organization of character building and religious education.

These rubrics should not be regarded as an adequate classification of the fields of applied psychology. They are listed merely as a suggestion for the purpose of showing the scope of this practical science.

Scope and purpose of elementary psychology. — In this book we shall pursue a general elementary introduction to the subject of psychology as a whole. It will deal primarily with human, adult mental life from the point of view of pure psychology; but, throughout, illustrations will be drawn freely from each of the various phases of psychology enumerated above, both pure and applied.

The first course in psychology should have certain aims, which also represent the results the student should seek. The primary aim is to train the student in the *observation and explanation of mental facts.* "*Not psychology, but to psychologize*" is to be our motto. Other aims are secondary; such as, systematic knowledge of mental facts; culture, the ability to interpret life; efficiency, the ability to use the mind effectively; appreciation of mental life for itself, which is the basis for the recognition of its worth and significance; a foundation for the mental sciences and arts, such as logic, philosophy, ethics, æsthetics, sociology, and education; a supplement to the material sciences in that we study the knower and the knowing process; and a preliminary to the various branches of applied psychology.

Exercise. — *Below is a list of words set by Thorndike as typical of the words in our vocabulary. Mark with* p *the words that denote physical facts and with* m *those that denote mental facts (marking with both* m *and* p *those that denote both, such as* dog).

gas	wish	inventiveness	heavy	pleasure
tree	dog	inch	sour	teeth
sympathy	stone	pound	oxygen	observe
money	dreams	taste	electricity	remember
desire	headache	intelligence	fatigue	image

There are as many words in the dictionary with mental connotation as with physical. There are as many mental phenomena subject to scientific study as material phenomena. The mental sciences may in the near future have as many branches and embrace as large scope as the material sciences.

As out of the pure physical sciences have come engineering, medicine, architecture, and other forms of applied material sciences, so in the near future will come the applications of psychology to education, medicine, industry, art, and all other varieties of human endeavor in which scientific knowledge of human or animal behavior can be made of practical value.

No science is more intimately and practically related to the conduct of human life than is psychology. It is, indeed, concerned primarily with those facts and principles of experience and action upon which our understanding of ourselves as conscious beings and our ability to understand and sympathize with our fellows depend.[1] In pursuing this study, we are following the advice of the old Greek philosophers: "Know thyself."

[1] "Only with the aid of psychology can one to the fullest possible extent reap the benefits of the study of the other sciences. Language cannot be understood; literature cannot be appreciated, read, and interpreted; art cannot be profoundly comprehended, and even the natural sciences cannot have their full import revealed without a knowledge of the mind of man. And, indeed, how could this be otherwise, since all science itself is only the product of the human mind." (Ladd)

"The historian strives today for psychological explanation, the economist for psychological laws; jurisprudence looks on the criminal from a psychological standpoint; medicine emphasizes the psychological value of its assistance; the realist, the artist, the poet fight for psychological truth; the biologist mixes psychology in his theories of evolution; the philologist explains the languages psychologically; and whilst æsthetical criticism coquets with psychology, pedagogy seems ready even to marry her." (Münsterberg)

"The essence of business is human nature. Whether we trade in commodities or ideas, we deal through human contacts. In the industrial world the importance of human relationships is constantly increasing." (Charles M. Schwab)

CHAPTER II

SENSORY EXPERIENCE

EXERCISE: *List all the kinds of sensation through which you can become aware of each of the following: (1) an orange, (2) a handshake, (3) a distant tree, (4) a beefsteak, and (5) hunger.*

Specialization and coöperation in the senses. — All knowledge of the world comes to us directly or indirectly through the senses. Each sense organ furnishes us its own particular kind of information in its own particular way — the eye in terms of color and form, the ear in terms of noise and tone, the nostrils in terms of odors, the tongue in terms of tastes, the skin in terms of temperature, pressure, and pain. There is a specialization in the senses which results in division of labor, economy, diversity, and effectiveness of experience.

But the senses also coöperate, furnishing simultaneous impressions of the same object, as was shown in the exercise, where we found that some objects or situations may be experienced simultaneously through five or six senses. Such coöperation leads to clearness, richness, and completeness of experiences.

Sensation and perception. — Sensation and perception together constitute sensory experience. Sensations are those elemental conscious processes which are ordinarily conditioned upon the functioning of the sense organs; or, as James says, "The first thing in the way of experience." Being aspects of consciousness, they

are purely mental. They do not carry meaning but constitute mere awareness of sense quality. Perceptions, on the other hand, are the interpretations of sensations and convey meaning. Thus, theoretically, we may experience redness, sweetness, fragrance, smoothness, and coldness, as sensations in eating an apple; but when these qualities are interpreted as representing an apple we have a perception. It will be convenient for us to study the processes of sensation and perception together as one complex process, because in normal experience our consciousness is nearly always of objects rather than of pure qualities.

Selective attention. — The vast mass of sense impressions pass unheeded. If you write your name slowly and with the greatest possible care, you will observe how there are present countless sensations of strain in joints, muscles, fingers, and arms, even extending to the muscles of the trunk and toes, which respond in sympathetic action with the movement of the writing hand. From tip to toe the whole organism is active when we write. All this complex of actions is reported in sensory impressions. Ordinarily these impressions of strain and movement which are involved in the writing of the name pass unnoticed.

Likewise, if you listen intently to some interesting material, you will observe that, when you are interested and off guard, your eyes are quite open; but just to the extent that you are interested in the things heard you see nothing. Of each thousand impressions made upon the eye, nine hundred and ninety-nine pass by unnoticed in normal life. This is characteristic of the

function of the other senses also, and is one of the fundamental expressions of economy in nature. We are continually bombarded through the senses with stimuli capable of arousing sensations; but we have acquired the habit of ignoring automatically those that are not needed. On account of the ever-presence, the faintness, the insignificance, and the vastness in number, only a small per cent of the impressions from the senses become conscious. The great mass remain below the level of consciousness and are regarded as subconscious. Functionally they are, however, of the same kind as conscious perceptions and play the same kind of rôle as conscious perceptions in the adjustment of the organism. We regard them as mental, although not conscious.

Classification. — How many senses have we? Our forefathers said five; most good literature is written in terms of five. But modern science has revealed new senses. The criteria of a new sense are: (1) that it shall furnish us an experience not furnished by any other sense; (2) that it shall have a sense organ of its own; and (3) that this experience shall be referred specifically to objective conditions. Applying these criteria, we find at the present time that we have nine senses. These may be classified psychologically, physiologically, and physically. The psychological classification is based upon the kind of sensation; the physiological upon the sense organ; and the physical upon the adequate physical stimulus. We thus obtain the three-fold classification which is exhibited in the parallel columns of the table following.

PSYCHOLOGICAL (*Sensation*)	PHYSIOLOGICAL (*Sense Organ*)	PHYSICAL (*Stimulus*)
1. Sight	1. The eye	1. Light waves
2. Hearing	2. Cochlear part of the ear	2. Sound waves
3. Taste	3. End-organs in tongue	3. Chemical energy in liquid form
4. Smell	4. End-organs in the nose	4. Chemical energy in gaseous form
5. Pressure	5. End-organs in the skin and internal membranes	5. Mechanical energy
6. Temperature	6. End-organs in the skin and internal membranes	6. Radiant energy
7. Strain	7. End-organs in muscles, joints, and tendons	7. Mechanical energy
8. Pain	8. End-organs in skin and internal linings	8. Many forms of energy
9. Equilibrium	9. Vestibular part of the ear	9. Mechanical energy[1]

Some have thought that hunger, thirst, and sex feelings are special forms of senses, but they do not qualify by the test of the three criteria named. It seems probable that each of these is simply a complex of other recognized sensation qualities. Thus, hunger may be reduced to sensations of pain, temperature, pressure, and strain.

Some animals may have additional senses. There are many possibilities. Think how different the world

[1] In current physiology the sensory end-organs are spoken of as *receptors* and are divided into three classes: (1) *the exteroceptors* (external) embrace the end-organs in the eyes, ears, nose, and the external skin; (2) the *interoceptors* (internal) are those which are located in the internal membrances, such as those of the mouth, pharynx, œsophagus, stomach, and intestines; (3) the *proprioceptors* (deep) are primarily the end-organs of pressure and strain embodied in the muscles, joints, and tendons, and the end-organs of equilibrium in the ear. The receptors in the eye, ear, and nose are also called *distance receptors*.

would be if we had a sense that made us aware of all the electrical forces around us! Indeed, there is force in the aphorism: Give me another sense, and I will give you another world.

The attributes of sensation. — We shall simplify our study of sensory experience greatly if we realize that all our knowledge of the world comes to us in four forms, namely: quality, intensity, time, and space. This fact gives us a logical basis for the classification of phenomena of sensory experience. Each of the senses reveals the world to us in terms of four attributes of sensation: quality (kind), intensity (quantity), duration (time), and extensity (space). These are the attributes of things. They are the forms in which we remember, imagine, think, and act about things. They, therefore, furnish us a complete basis of classification which shall be maintained explicitly or implicitly throughout our study of psychology.[1]

Quality simply means kind. Thus, we have these kinds of sensation: colors, brightnesses, tones, odors, tastes, pressures, strains, temperatures, and pains. So far as we know, we have no other kinds of sensation. *Intensity* merely means quantity, or strength; *i.e.*, how much of the quality. In vision, intensity refers to the degree of light; in hearing, to the degree of loudness of the tone; in taste, to the strength of the taste; in pressure, to the degree of pressure, etc. Likewise,

[1] Some psychologists question this classification. Thus, it is not fully known whether all senses possess the attribute of extensity. Some think clearness is an attribute of sensation, while we regard it as an aspect of attention. Others claim that agreeableness and disagreeableness, as "affective tone," are attributes of sensation; we regard them as feelings. These are, however, largely matters of terminology.

the concept of *duration* is self-explanatory. It refers to how long the color, the tone, the taste, or any other sensation lasts. The nature of *extensity* is, however, not so evident. Seeing form, hearing direction, locating pressure, are complex matters of perception of space; but the original and elemental experience of space in the form of sensation we call extensity.

The sensation is its quality. Thus, awareness of redness is a sensation of color. The other attributes merely indicate variations in the intensity, the duration, and the extensity respectively of this quality. Yet, no sensation can exist without intensity; no sensation can exist without having some duration. It is an unsettled question as to whether or not we can have any sensations which do not imply extensity. To recapitulate, we know the world in terms of quality (kind), intensity (quantity), duration (time), extensity (space), and we know nothing of the world except in these four terms. Each sense gives us a particular kind or class of impressions, and each of these impressions may vary in intensity, duration, and extensity.

The limits of the senses.—Each sense organ is a limited instrument. Therefore, in each sense we have for each of the attributes two limits, usually called the upper and lower. Physically, there are tones so high in pitch (quality) that the ear does not register them, and tonal vibrations may be so slow in frequency that the ear does not grasp them as a tone but as individual puffs. Tones may be so strong (intensity) that they injure the ear; tones may be so faint that the ear does not register them. Ordinarily the ear is capable of

hearing the shortest (duration) physical sound, *e.g.*, an electric spark, and can listen indefinitely to tones of moderate loudness; but actual limits exist due to inertia and fatigue of the ear. The difference in the direction of tones (space) may be so small that it cannot be heard; tones may be so diffused that they cannot be located accurately. The same type of limits may be found for most of the other senses.

That means that we get only a partial report from the outer world. In the limits of the senses nature has set up a medium of selection by means of which our consciousness is limited in large part to just the information we need, and we are freed from the burden of the infinite possibilities of non-essential impressions. On the other hand, it is interesting to speculate as to what would happen if our senses were extended; *e.g.*, so that, instead of seeing only one octave in the rainbow of colors, we could see octave upon octave of rainbow colors in harmonies.

Sensitivity. — The lower limits of each sense are measured in terms of sensitivity, usually spoken of as the threshold of sensation, meaning the faintest impression that can be perceived. This threshold has become an important index and the conventional foot-rule for psychological measurements. Individuals differ in this sensitivity: one person may be two, ten, twenty, one hundred times as sensitive as another; and this capacity can be measured with satisfactory accuracy by modern methods. Thus, we can express quantitatively how sensitive any person is to a particular color, tone, taste, or pressure. Under ordinary conditions the limits

of sensitiveness are set in the structure of the sense organ, and sensitivity is the measure of the condition of the organ, but there may be other causes.

Discrimination. — Discrimination is the capacity for perceiving differences. It is measured in terms of the "least perceptible difference" (l. p. d.). This difference is called the threshold of difference, or simply discrimination. Thus, the discrimination for blue is measured in terms of the smallest difference between two blues that a person can perceive. Since capacity for discrimination is an index to capacity for the use of a particular sense, this measure assumes a coördinate position with that of sensitivity in the study of individual differences.

Thus, we have the two measures: sensitivity, the measure of capacity for receiving an impression; and discrimination, the measure of the capacity for differentiating impressions. Any person may be high in one and low in the other in any of the attributes in any of the senses. Measurements of these capacities enable us to account for many instances of success or failure, and to predict success and failure, as well as the character of a person's interest in things.[1]

Sensory defects. — Any defect in the sense organ, whether congenital or acquired, structural or functional, results in a corresponding loss of mental capacity, and literally makes the world seem different. On this point

[1] A person may be totally deprived of any one or more of the senses. Thus we have blindness, deafness, anosmia (loss of smell), ageusia (loss of taste), and analgesia (loss of pain). Sensory defects are frequently congenital; but healthy sense organs are so delicate that even under the most favored circumstances injury, deterioration, or arrested development almost invariably takes place to some degree before a person reaches middle age.

students should by all means read Helen Keller's little book, "The World I Live In." She lost sight and hearing and became dumb in infancy and has given us a wonderful account of the world in which she lives. She lives in the "lower" senses the life of one of the most intelligent, appreciative, and effective women of her time. The psychology of this is profoundly illuminating.

The evolution of sense organs and sensation. — The evolution of sensation is parallel to the evolution of the sense organs. Each is conditioned by the other. The original sense in primitive animals was probably a bare sense of contact or undifferentiated touch. The animal endowed with this sense could guide itself to a limited extent with reference to objects with which it came in contact. Under these conditions no high degree of mental development would be possible. Some part of the skin eventually became sensitive to light, a sort of primitive "chemical" sense, and from this evolved the wonderful structure of the eye which gives us the sense of "touch at a distance." This eye was originally merely capable of registering light and gave neither color nor space. After geological ages, a crude lens was gradually formed with the accessory mechanism necessary for giving information about size, form, and distance of objects. Much later than this the primitive retina became sensitive to color by means of which the eye could give information about the quality of objects known through color. Thus seeing animals gained a mastery of a large environment, being able to guide themselves with reference to the location and character of objects at a distance.

But the eye functions only in light, and only in the direction in which the eye is turned. Animals, therefore, needed another sense to guide them with reference to objects in the dark and behind or otherwise out of sight. In response to this need the ear, which had long been in existence as an organ of equilibrium, became differentiated into two parts, of which one is the organ of hearing. But the organism was still in vital danger of consuming as food something which might be injurious because the qualities of danger could not be told effectively through touch, sight, and hearing. The original organ of contact, through the "chemical sense," therefore developed a specialized organ in the mouth as a guardian of the alimentary canal. This became the sense of taste. But even taste as a guardian is of limited capacity, because it does not inform us of the quality until the material has been dissolved in the mouth. There was also need of a guardian of respiration to protect the lungs from inhalation of noxious substances. For the purpose of giving information about food and sex objects at a distance, the original and primitive chemical senses developed specialized organs in the nose, which became the sense of smell, giving information about the nature of particles in the surrounding air and especially objects which might be presented to taste or touch. Thus smell became "taste at a distance." And far back, where special muscles began to develop, the sense of touch became differentiated into pressure and strain. The former was located in the skin, the latter in the muscles, tendons, and joints. In a general way, the former represents the original sense of contact, the latter its

opposite; namely, strain or pull, which gives us information about the position and movement of parts of the body. And, with further increasing need of maintaining an upright position or balance, there developed out of the senses of strain and pressure the system of the ear which constitutes the sense of equilibrium. Still another differentiation took place. As the organism developed, there came a need of a guardian of the organism as a whole, — a sort of general guardian, both external and internal, — and out of the original sensory contact came the new organs of pain.

No significance should attach to the order in which these have been mentioned. In general it is undoubtedly true that there has been a gradual differentiation from a single primal sense which we have called the sense of contact. The higher evolution of all of the senses has been a parallel process, as a high development in one sense is conditioned upon corresponding development in other senses both mentally and physically.

This picture has been drawn from the point of view of the preservation of life; but the higher the animal, the larger are the needs and the means of enrichment, enhancement, and enjoyment, as apprehended through any sense. Therefore we shall find that pleasure and power for varied achievement are as potent features as the mere need of protection and preservation in the evolution of the senses. One is defensive; the other is aggressive. Nature is prolific and generous.

In this evolution of the sense organs and sensation, we establish a close relationship between man and animals. The psychologist has, therefore, a double in-

terest in the study of evolution in animals: first, the fascinating story of the origin and mode of development of the senses of man through the animal series; and, second, the interest in psychology of the animal mind itself. In general, the higher animals have the same number and the same kind of sense organs as man. Sometimes they are less differentiated, but at other times they may be more highly specialized and sensitive. The difference between man and animal in this respect lies not so much in the sense organs and sensory impressions themselves, as in the capacity for making intellectual use of them.

Development of the senses. — Structurally the sense organs are perfected at birth and assume no new capacity thereafter. The so-called development of sense capacities in the child consists, therefore, essentially in the gradual accumulation and organization of sensory experiences. Each new experience is set or interpreted in the light of all the past experiences. This process of developing a setting for experience results in the development of sensory meaning, or perception. Although the infant reacts to sensory stimuli at, and even before, birth, the impressions probably carry no meaning. The eye registers the signs of form, distance, and direction, but the infant does not see form or distance of objects. Recognition of objects and other relations and uses has to be learned gradually for each and all of the senses for themselves, and in coöperation. In all this unfolding or learning, there is natural law, beautiful orderliness, and most unfathomable richness in the possibilities of experience.

CHAPTER III

COLOR VISION

Visual Qualities. — We live primarily in a visual world and most frequently think of objects as they "look." Sight is the dominant intellectual sense; it acquaints us with objects in terms of brightness, color, and space. (For structure of eye see Appendix, Figs. 28–30.)

The eye gives us two series of visual qualities: color in the rich series as seen in the rainbow or the spectrum; and brightness, or colorless light, as seen in the series of grays from black to white inclusive. Brightness is always present in color. For this reason it is convenient to discuss color and brightness together and to use either of the two terms broadly to designate the two series as in the heading of this chapter.

Color may be studied from three points of view: physics, the nature and laws of light waves; physiology, the function of the eye, the nerves, and the brain in vision; and psychology, the description and explanation of the nature and laws of our perception and appreciation of color and brightness.

The physical source of color. — Physically color is due to light waves of an electromagnetic nature. The waves to which our eyes are sensitive cover less than one octave, while rays of the same nature have

been recorded for about fifty-four octaves. Those of lower frequency, *e.g.*, 100,000 vibrations per second and upward, are used in wireless telegraphy. Between these and the visual range we have the infra-red which may be registered physically, but the eye is not sensitive to them. Above the visual range are ultra-violet rays and above these are x-rays and related rays. The same rays that generate light also generate heat.[1]

Our common names for colors are loose and arbitrary. A color is defined precisely in terms of the vibration frequency (the number of trillions of vibrations per second) or its reciprocal, wave-length, as is shown in the following table. The range as here given is less than an octave. Since we have registered more than fifty octaves

Color	Number of Trillions of Vibrations per Second	Length of Wave in $\mu\mu$ or One Millionth of a Millimeter
Red	390	760
Orange . . .	509	587
Yellow	521	577
Green	500	600
Blue	625	480
Violet	755	396

[1] Light is generated by luminous bodies such as solids, liquids, and gases of high temperature, flames, and electrical discharges. The perception of objects is made possible by the indirect generation of light from non-luminous objects through (1) refraction, as in the rainbow, halo, and prism; (2) interference, as in the soap film, the opal, and Newton's rings; (3) diffraction, as in colors inside shells, the corona, colors seen through eyelashes and gratings; (4) scattering, as in the color of the sky and sunset colors; (5) absorption, as in colored glass and fabrics; (6) selective reflection, as in metals and metallic colors of certain insects; (7) fluorescence, as in kerosene; (8) phosphorescence, as in phosphorescent things; (9) interference by polarized light, as in certain crystals.

of the same kind of waves, it is interesting to speculate as to how the outer world would look if our eyes were sensitive to a wider range of colors. The analogy of octaves in music suggests a richness of possibilities in series upon series of harmonies in colors.

The color variables. — Colors vary in three respects: hue, brightness, and saturation.[1] The hue is the color quality proper; brightness denotes the relative amount of white light with or without color; and saturation denotes degree of purity of color. A color is said to be pure when it is caused by a specific vibration frequency; *e.g.*, red of the wave-length 700 $\mu\mu$ is a specific pure red; when caused by a mixture of a considerable range of wave-lengths, the color is said to be impure or mixed. White light or mere brightness results from simultaneous stimulation by all wave-lengths. Tints and shades are variations in brightness: when the brightness is lighter than the color at its best in greatest saturation, we call it a tint; when darker, a shade.

The four colors red, green, yellow, and blue are said to be primary or elementary; all other colors may be produced by appropriate mixture of two or more of these. Thus, orange is a mixture of red and yellow; purple, of red and blue; olive, of yellow and green. The primary colors consist of two complementary pairs: red-green and yellow-blue. The complementary colors are always opposite or physiologically antagonistic. If mixed in suitable proportions, they cancel each other and result in mere brightness.

[1] There is great diversity of terminology on this point. The following are used synonymously: (1) hue, color-tone; (2) brightness, luminosity, intensity, and tint and shade; (3) saturation, purity, chroma.

The color pyramid. — All the relations of hue, brightness, and saturation are well illustrated in the color pyramid, Fig. 1. Let the spectrum of colors be spread in a band, red, yellow, green, and blue, around the base of a double pyramid. On the theory of color mixture, all possible grays may be represented as a linear series of brightnesses in the axis white to black. A straight line drawn from any point in the spectral band through this axis to the opposite side will connect two complementary colors, the mixture of which will result in gray. A mixture of any two colors of any particular brightnesses may be represented by a point between the two in the pyramid, showing the relative amount of each of the two components and the relative grayness of the mixture. Mixtures of colors may be represented in the surface.

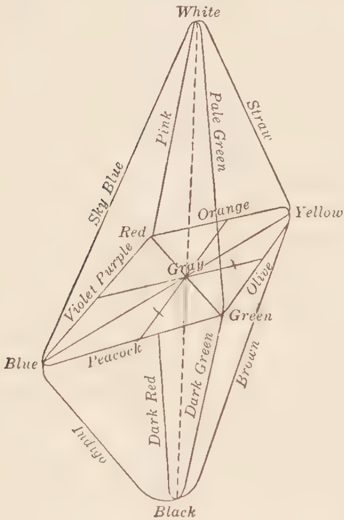


Fig. 1. — The color pyramid (from Calkins, after Titchener)

Color mixing. — The most exact method of mixing colors for experimental purposes is furnished by the spectro-photometer, an elaborate prism apparatus; but, for most demonstrational purposes in psychology, we use the color mixer, which is a motor that revolves interlocked color discs. This method of color mixture

is based upon the retinal lag; *i.e.*, the fact that the impression of one sector lags on the retina until the wheel has revolved enough to expose another sector so that the two fuse on the retina.[1]

The following phenomena might well be demonstrated with the color wheel: (1) with a black and a white disc, produce a large number of grays from pure white to pure black; (2) with pairs of complementary colors, produce neutral grays; (3) with pairs of adjacent colors, produce mixtures; (4) with a color and white, produce a series of tints; or with a color and black, produce a series of shades of color; (5) with a mixture of two colors and black, produce a shade of the mixture; (6) with a mixture of two colors and white, produce a tint of the mixture; (7) with three colors (red, green, and blue), produce a gray; (8) with a mixture of black and white on the small disc, match the brightness of red in the large disc; (9) with black and white on a small disc and black and white on the large disc, produce a series of steps of just noticeable difference in brightness; (10) using red and yellow in the same manner, produce a series of steps of just noticeable differences from red toward yellow; (11) take any colored fabric and match it on the color wheel.

The number of colors. — Psychologically, the number of colors that exist is determined by the number of color differences that we can see, as in experiments 10 and 11, above. Thus, under the most favorable conditions, trained observers can see about two hundred differences

[1] A color wheel may be made very simply by putting an arbor on an ordinary fan motor. The kindergarten color top (Milton Bradley, Springfield, Mass.) costs only a few cents and will serve most of the purposes of the color wheel.

in hue from one end of the spectrum to the other. We can see six or seven hundred shades of gray between black and white. We can probably see more than one hundred tints and one hundred shades of each color. We can see a large number of mixtures of any two or more non-complementary colors. Counting all these modes of perceptible variation, it is estimated that the normal person can see at least 30,000 color and brightness differences.

Sensitivity and discrimination. — Sensitivity is measured in terms of the least perceptible stimulation; discrimination is measured in terms of the least perceptible stimulus difference. Both may be illustrated with the color wheel.[1]

There are enormous differences in the sensitivity to color. One person may be relatively sensitive or blunt to any or all of the colors, ranging from most extreme sensitiveness, through all degrees of color weakness, to complete color-blindness for one or more of the colors. A person may be sensitive to color and still lack the power of discrimination; *i.e.*, the ability to make use of color differences. Weber's law is to the effect that in general the least perceptible difference is proportional to the intensity of the stimulus. Thus, if we can perceive a difference of $\frac{1}{100}$ in the brightness of two candle lights, we should expect to be able to see the difference of $\frac{1}{100}$ in the brightness of two arc lights. This law is found to be very useful in practical affairs.

[1] The most convenient instrument for this purpose is the Lovibond tintometer. A satisfactory substitute may be made by arranging a graded series of solutions of colored liquid in small flat bottles.

Brightness and color contrast.

EXERCISE. — *(1) Cut two narrow strips about 5 mm. wide from a piece of uniform gray paper or cloth. Lay one upon a white surface and the other upon a black surface, and if available cover them with a sheet of tissue paper and observe that the gray on the black background is very much lighter than the gray on the white background. This is the phenomenon of brightness contrast. (2) In the same manner take two strips of color and lay them on different colored backgrounds, covering them with tissue paper, and observe that the color of each of the colored strips has changed in the direction of the complementary color of the background.*[1] *Write a brief report.*

Among the countless illusions of color, that of contrast is undoubtedly the most persistent and significant. Every hue and brightness in nature and art is modified by adjacent hues and brightnesses in the direction of the greatest opposition. Usually we speak of the larger surface as the inducing area and the smaller as the induced; but the effect is reciprocal, although it is proportionately greater for the smaller area.

The laws of contrast are well known and may be seen to operate in nature and art wherever colors or lights occur on contiguous surfaces. They must be regarded for appropriate effects in all art, decoration, dress, etc. Thus, by placing a red upon a green background, it is possible to produce a more brilliant red than could otherwise be produced. A tint of an undesirable color may be cancelled by placing around it a patch of the same color. All colors may be enhanced or softened by introducing appropriate contrasts.

The contrast effect is strongest at the adjacent mar-

[1] In lieu of this exercise take Chapter II of the author's Manual of Elementary Experiments in Psychology.

gins. It may be enhanced, *e.g.*, by extreme differences in color and brightness, by looking only for a short time, by a large inducing and a small induced field, by proximity of the two fields, by softness of contour and the blurring of edges.

After-images.

EXERCISE. — (*1*) *Make a black ink blot about the size of a dime on a sheet of white paper. Fixate it; i.e., look at it without moving the eye, from five to twenty seconds; then turn quickly and look at one point on some neutral surface, such as a gray wall, and for a few seconds you will see the blot not black but white.* (2) *Fixate as before, but in this case close your eyes and project the after-image somewhere in space in front of your closed eyes. Fixate it again and project the image upon the white paper a short distance away from the dot. You will see the black dot as a white dot whiter than the paper.* (3) *Similarly fixate a bit of bright color in these three ways, and in each case you will see the object in the complementary color. These images are negative after-images of color. Write a brief report.*

Here we are dealing with a universal tendency in light; namely, the tendency of impressions to persist after the stimulation has ceased. There are after-images of color and after-images of brightness. Each of these is of two kinds, positive and negative. In the positive after-image the color and brightness are similar to the original; in the negative they are opposite; *i.e.*, brightness is reversed and colors appear in their complementaries.

Under strong stimulation after-images recur as often as six or eight times after a single stimulation. In such a series the positive and negative after-images alternate. The positive after-image appears first and is of very short duration and, therefore, is not easily observable by a beginner; after a blank, this is followed by a negative

image, which may last from one to fifteen seconds at a time. Pure hues and intense brightness produce the most marked effects. A fixation time of five to twenty seconds is favorable, although it varies with many conditions, especially with training. The image of a small and sharply defined object is more readily observed than that of a large or ill-defined object. The effect is best when the image is projected upon the background differing from it in brightness and hue. The hue and brightness of the image always mix with the hue and brightness of the surface upon which they are projected. The relative brightness and saturation of the image depend upon the intensity and saturation of the stimulus.

We must not think of the after-image as occurring only under such specific conditions. It is ever-present in normal vision. The after-image of one object is produced upon the next object; or, if we continue to fixate one color or light, it modifies this color or light. The result is that things look different according as we see them after other objects or for a certain duration of time. In ordinary life we do not notice these phenomena, partly because the effects are so countless and apparently chaotic, and partly because we do not look for them or recognize them when we see them. In viewing a bouquet of variegated colors, the image of each color and light affects our perception of the next.[1]

[1] This explains many bothersome phenomena of vision. In church, *e.g.*, the listener may observe strange and persistent figures, moving across a blank wall. By a little effort he may be able to trace this "writing on the wall" to the organ pipes, the flag, flowers, a bit of white drapery, a black draping, etc. The form can be recognized; the figures move with the eye. Many ghosts, visions, and apparently miraculous appearances have been made of this innocent stuff.

Adaptation. — The positive after-image is due to a persistence of the same physiological processes which occur in primary vision. Negative after-images are local effects of the general phenomenon of adaptation in the retinal elements. Indeed, after-images have been defined as localized adaptation. The short duration of an after-image and the shift from positive to negative are due to a fundamental tendency to periodic action in the retina. Even in the after-image of white light the complete cycle of colors, sometimes called "the flight of color," may be seen periodically. In general, the law of adaptation is to the effect that under prolonged stimulation black and white tend toward a uniform gray, and colors tend in the direction of mere brightness. When we go from a dark room into a bright light, the light is harsh; when we go from a light room into a dark room, the darkening is striking, but in both cases the eye soon adapts itself. This is due partly to contraction or expansion of the pupil, but more fundamentally to the change in the retinal elements. The same is true about color. Wear green spectacles for a while and the objects at first so harshly green soon lose their color. A highly colored object or environment is much more impressive at first than after reasonable adaptation.

Closely related to this is the phenomenon of twilight vision as distinguished from daylight vision. Colors appear very different in dim light from what they do in bright light. In daylight yellow is the brightest color, but in twilight green is the brightest. As darkness comes on the colors of the spectrum gradually vanish.

The retinal light.

EXERCISE.—*Close your eyes and cover them well and observe that under these conditions you will see a most gorgeous display of colors. There are countless patches or masses moving continually in kaleidoscopic change. The better the eye is darkened the more striking is the display. Write a brief report.*

This is the phenomenon of retinal light or "own-light" of the retina. It is caused by the internal stimulation of the retina, *e.g.*, by circulation and metabolism. At night in a dark room these colors become conspicuous and have been called the "stuff that dreams are made of." The causes of these phenomena are present in daylight, but the effects are drowned out by the flood of daylight and meaningful impressions.

Color fields.

EXERCISE. — *(1) Take a white paper about an inch square and, holding it out at arm's length, bring it into the field of vision gradually from the left, using the left eye only, and observe how far out you can see it when the eye is fixed upon an object straight in front. (2) Try bits of colored paper in the same way and observe that colors do not first appear in their true color and that the limits for seeing the true color are different for different colors. By repeating this on several radii we may map the field of vision for each color and for white. Write a brief report.*

The retina is like the sensitive plate of the camera in that a copy of the external object is thrown upon it. The most sensitive point of the retinal screen is called the fovea; the outer edges, the periphery; the field between the fovea and the periphery, the indirect field. We may speak either of the retinal area or of its reciprocal, the visual field. There are three clearly recognized zones in the retina, as shown in Fig. 2. The outermost,

in to *Y — B*, is sensitive to light only. In this region both light and colors appear gray. The middle zone is the yellow-blue zone. Here lights and grays are

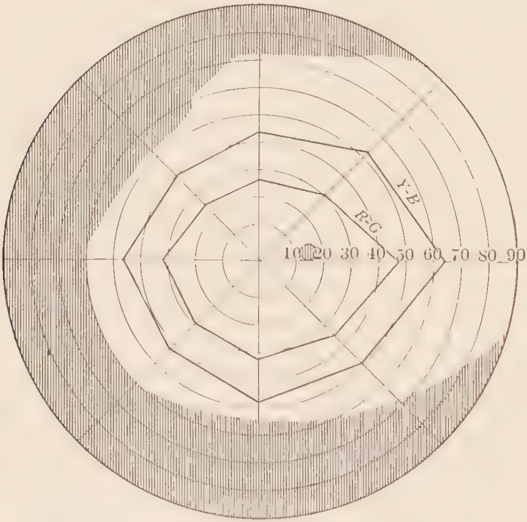


FIG. 2. — Color and visual zones (Baird)[1]

seen approximately in their true brightness and the colors yellow and blue with all their derivatives and mixtures may also be seen. The innermost zone is red-green. Here all colors and brightnesses may be seen, and with approximate correctness as we approach the fovea. The significance of this zonal arrangement with respect to evolution of color and the explanation of color-blindness will be seen presently.

[1] This figure is in accord with the Hering theory. The facts upon which it is based are exceedingly complicated both in theory and observation, and a great diversity of opinion prevails.

Among the laws of indirect color vision are the following: All colors are seen at their best in the central field, at the fovea. The outer limits for the field of red-green coincide; the outer limits for the yellow-blue field coincide; the yellow-blue field is always the larger. All colors and lights enter from the periphery as grays in the outermost zone. All colors, except the four primary colors, go through definite cycles of change when passing anywhere through the two color zones. The saturated, primary colors, red, green, yellow, and blue, do not change in hue in indirect vision. All colors when seen by indirect vision go through a definite series of changes, covering the complete cycle of the spectrum in a very few seconds; *i.e.*, the colors in the indirect field are very unstable and the process of adaptation is very rapid, but follows definite laws.

The blind spot.

EXERCISE. — *Look steadily with the left eye only toward an object straight in front and, starting in this line of regard, move a small coin slowly to the left at arm's length until the coin disappears (at about 20° or 30° out). This blind spot corresponds to the small area in the retina which is blind because the optic nerve enters there. Observe and state how we fill this absolute blind spot in normal vision.*

These phenomena of indirect vision add enormously to the complexity of our color vision. If we could observe a surface uniformly colored and uniformly lighted in all parts for a few seconds, we should see simultaneously at any moment all the colors of the spectrum, and the whole color mass would be in constant flux according to a definite law of change for each degree of indirect vision.

The periphery of the retina is more sensitive to light and movement than the central field. This is of biological significance because the outer fields serve as scouts picking up indications of approaching objects. On the other hand, the central retina registers space and color more accurately. Hence, whenever we want to see an object we automatically turn the eyes so as to throw the image upon the fovea. This is a most wonderful mechanism of specialization and economy, leaving a large area sensitive for scouting and a small central area highly developed and not easily fatigued for the accurate perception of objects.

Physiological theories of color vision. — The full explanation of color vision includes an account of (1) the nature of the experience, (2) the laws of color vision, (3) its evolution, (4) the natural physical stimulus, and (5) the nature of the physiological process. At this last stage we strike the greatest difficulty in that, while there is a mass of excellent experimental evidence at hand, there is no general agreement in regard to the nature of the mechanism and its evolution. Each and every phenomenon of color vision has its physiological explanation; but in many respects physiologists simply do not know at the present time just what it is.

On certain facts, however, all are agreed. The end-organs of color vision are found in the retina, primarily in the layer of rods and cones. These receptors are sensitive to electromagnetic waves of approximately 400 to 800 trillion vibrations per second. Each particular vibration frequency results in a specific color: from the red at the lowest frequency up to the violet at the

highest. Light or brightness is ordinarily caused by the simultaneous stimulation by all vibration frequencies within the spectrum. Each specific frequency also has an inherent light or brightness value, yellow being the brightest and blue the darkest in good daylight. There is probably a small number of specific color elements which correspond to the primary colors: according to the Young-Helmholtz theory three, red, green, and blue; according to the Hering theory three pairs, red-green, yellow-blue, and black-white. For every phase of color experience there must be a corresponding physiological condition in the physio-chemical changes in these elements.

The evolution of color vision. — The first stage of the light organ was probably merely a light-sensitive spot of pigment at the surface of a simple organism. This gradually differentiated into a specific light-sensitive group of cells. These spread on the inside of a gradually formed eyeball, and became the retina. This retina was probably first sensitive to movement and to light only; but gradually a new function was taken on — that of yellow-blue vision. The animal at this stage could see light, or white, and yellow-blue and all their derivatives. Geological ages later another differentiation took place, and the central part of the retina became sensitive to red-green and its derivatives. Each color element started at the center of the retina and gradually spread outward. Thus it is that the yellow-blue field of color is larger than the red-green, which has not had time to grow out so far.

Color-blindness. — About four men in a hundred

and about one-tenth as many women are color-blind. The commonest form of color-blindness is red-green blindness. A red-green blind person cannot tell the strawberry from its leaves by color. Reds and greens are alike to him, although there are many gradations of the red-green type. Since all colors that we encounter in nature or fabrics are mixed, the red-green-blind person sees not the reds and greens of the ingredients, but the yellows and the blues. Pure red and pure green he sees as grays. A color-blind person may pass through life without ever discovering that he is color-blind. He may use the names, and he ordinarily thinks that other persons see colors as he sees them. Red-green color-blindness finds a natural explanation in the biological law that the last-acquired traits or capacities are the least stable, and therefore the first to be lost: specifically, red-green vision is the last acquired, and it is the first to be lost. Some claim that we cannot have yellow-blue blindness without also having red-green blindness.

There are many other forms of color-blindness. The extreme form is total color-blindness. Persons so afflicted see no colors. What is to us a richly colored world they see in blacks, grays, and whites, as in a photograph. On account of the uncertainty in color theories, there is much dispute in regard to the classification of types of color-blindness. In turn, color-blindness has offered the best opportunity for testing the validity of color theories.

True color-blindness is hereditary. In some peculiar way it is a sex-linked trait; it is prevailingly men

that are color-blind, but this trait is transmitted on the female side; *e.g.*, the daughter of a color-blind man, though not herself color-blind, may transmit the trait to her sons, while the son of the color-blind man will not be color-blind and will not transmit the trait. True color-blindness is not curable. It is due to congenital condition in the visual elements of the retina. Analogous defects may, however, be acquired and may then be curable. Tobacco blindness, *e.g.*, usually attacks the central region of the retina causing the person suffering from this ailment to acquire the habit of viewing objects in indirect vision when he wants to see colors; but abatement of the use of nicotine may result in recovery.

A mild form of color-blindness, very common indeed, is called color weakness. It may be weakness for one, two, or more elements and may be in any degree from true color-blindness to normal vision. Seamen, railroad men, and others, whose signals are given in color, are now tested for color-blindness as a protection to life; but, in the interest of efficiency and safety, tests for color weakness as described under sensitivity and discrimination may be even more important.

Color vision in animals. — The color vision of animals can be investigated by the behavior methods; *i.e.*, animals are taught to associate something desired, such as food, with a color signal, and by varying the signal it is possible to measure roughly the discrimination for color and for brightness. In these experiments it is extremely important to control the brightness as well as the hue and saturation, because all higher animals have some

degree of brightness discrimination and colors can be distinguished by their brightness. In general, although there is some experimental evidence in the negative, it seems possible that the higher animals have color vision somewhat analogous to the human. Birds have a retina quite like our own, but their spectrum seems to be shorter at the violet end. Reptiles resemble birds in color vision. No clear case of color vision has been found in fish.

Evolution of color vision in the race. — Historic man, of all ages, has probably possessed a form of color vision characteristic of present man so far as the mechanism is concerned, because many of the higher animals have it and there is no important difference in principle. Primitive man probably guided himself by color, as animals do, without being conscious of the color in itself or having names for colors. In all primitive races color names have arisen gradually, beginning with distinctions between light and color, then differentiating more and more colors in turn as they become prominent in experience. Untutored people confuse color and brightness. Red is the color which first attracts the attention of primitive man. The reason for the early consciousness of red lies partly in the inherent exciting nature of red, in its association with fire, blood, and brilliancy in an object, and in its rareness as compared with the blue of the sky and of the sea and verdant nature. The ability to use names of colors is gradually acquired by persistent education of the race. The common man of to-day has far to go in this respect.

Development of color vision in the child. — The color

vision mechanism is probably completely evolved at birth, and aside from minor physiological adjustments, it is quite certain that the child is sensitive to colors soon after birth. There is experimental evidence to show that the child sees all the colors at the age of three months, if not before. But, as in the evolution of the race, so in the development of the child, the consciousness of color, the use of color, the organized knowledge about colors, and precision in the observation of color vision is a gradual development. Common people see and use colors with an awful crudeness. Art and education are practically limitless in their possibility for the refinement of knowledge, appreciation, and use of colors.

CHAPTER IV

VISUAL SPACE

We do not have sensations of space; we perceive space. What we sense of the outer world is visual qualities of brightness and color and the quality of strain in eye balance and movement; the awareness of visual space relations is an act of interpretation of these. It is a complex act of perception.

If we look into the clear blue sky with no form or limits in view, the brightness and blueness of the sky seem to have an inherent bigness. This attribute of bigness, or extensity, may be regarded as the spatial attribute of sensation which forms the nucleus of our visual space.

The planes or dimensions of space. — Psychologically, there are two dimensions of space; the first dimension at right angles to the line of regard, and the second dimension, parallel with the line of regard. In general, points in the first plane indicate direction; in the second, distance. All other space relations may be regarded as combinations of these two. Within the first dimension we recognize form, size, direction or position, and movement; within the second, distance, relief or perspective, and volume. Space in the first dimension is seen with one eye; but adequate perception of

space in the second dimension requires two eyes[1] (Figs. 28–30).

Monocular Space

The retinal image. — The mechanism for the image formation consists of (1) the iris diaphragm, which limits the amount of light that shall be admitted through the pupil; (2) the lens system, which bends the rays of light in such a way as to bring them to a focus upon the retina; and (3) the retina, upon which the image of the object is to be projected. The light waves striking the area of the image set up nerve impulses which are transmitted to the brain in such a way as to serve as a sign of location. "Local sign" is that special character of a sensation whereby we are enabled to refer it to a particular place, "that differential quality of a sensation which varies with the part of the sensitive surface stimulated, but not with the nature of the stimulus." (Stout)

Accommodation. — The adjustment of the lens for varying distances, as in the focusing of a camera, is called accommodation. It is accomplished by a change in the curvature of the lens through the action of the ciliary muscle on the capsule in which the lens is suspended. As in the camera the eye can secure a clear image only at one distance at a time.

Defects in the lens system lead to corresponding defects in vision, called errors of refraction: (1) *myopia*, or nearsightedness, in which the focal length of the lens

[1] **The problem of the eye.** — "A mosaic of localized sensations of light and color must be so constructed that changes in the quantity, quality, local coloring, and sequence of these sensations shall be interpreted as the size, shape, locality, and motion of external visible objects." (Ladd)

system is too short; (2) *hyperopia*, or farsightedness, in which the lens system is too long; and (3) *presbyopia*, or old-sightedness, in which the focusing lens is hardened; and (4) *astigmatism*, in which there is unevenness in the surface of the cornea or the lens. These and many other eye defects are becoming more prevalent under the modern conditions of eye-strain and nervous pressure.

Eye-movement. — As we may register observed differences in direction in terms of degrees of a surveying instrument, so we register direction of the turning of the eyeball in terms of energy of eye-movement. The eyeball is delicately suspended and can be turned in any direction within its range by means of the six large muscles. In normal vision the eye is in lively motion. We can readily observe these movements, but they are much finer and more numerous and rapid than we ordinarily realize, as is demonstrated by motion pictures of the eye in reading or in looking steadily at a single object. What happens in ordinary vision is that the eye takes a vast series of snapshot views from different positions, so that what we really see is the summation of these pictures in a single mental picture or percept. In seeing, *e.g.*, the passing of a vehicle, size is registered in terms of the angle of eye-movement, position or direction from the observer at a given movement in terms of the turning of the eyeball from its point of rest, direction and rate of movement in terms of eye-movement in following the object.

Secondary criteria. — There are many secondary criteria by which a person with one eye can get a serviceable interpretation or inference about space in the second

dimension. (1) Knowledge of size: we know the approximate size of common objects, and knowledge of approximate size furnishes approximate knowledge of distance.[1] (2) Shading: the toning of the color and brightness suggests relief in a natural object as in a picture. (3) Sensations of accommodation: the strain of accommodation is an index to distance within a limited range.[2] (4) Clearness[3]: fine detail can be seen inversely in proportion to the distance. (5) Relation to known objects: shadows, objects in front or behind one another, motion, and many other circumstances in the relation of one object to another may be an indication of distance. Therefore, while lacking the proper means of seeing space in the second plane, a one-eyed person can guide himself quite effectively by sight and enjoy the feeling, more or less illusory, that he sees distance.

Binocular Space

Exercise. — (*a*) *Hold a pencil twelve inches in front of the eyes and a finger at arm's length. Fixate the pencil with the two eyes and observe that you see two fingers. Fixate the fingers and you will see two pencils. State why.*

(*b*) *Hold a closed book at arm's length upright and with back toward you. Look first with one eye and then with the other, and then observe that each eye gives a different view of the book. State why.*

[1] A blindfolded person was taken into a dark room in which he could see nothing but a one-half inch disc of red light. Asked to judge the size and distance of the object with one eye uncovered, he hesitated: "If it is near, it is small; if it is large, it is far away. That is funny! It may be the size of a pea, or a saucer, or a cartwheel!"

[2] This might be regarded as a primary criterion.

[3] Difference in clearness of the atmosphere called aërial perspective affects judgment of distances. Two men in a fishing party were standing on shore in the early evening and, as a third man stood up in his boat waving a lantern, one said to the other, "How tall is Bill?" "About seventeen feet," was the prompt reply. "That is the way he looks to me," said the inquirer. The fog had come up at dusk. *Explain in terms of geometry.*

With two eyes we see space in the first dimension, just as with one eye; and we have the same secondary criteria for interpreting distance. But with two eyes we see space truly in the second dimension by means of disparate images and binocular movements.

Double images. — Experiment *a* above illustrated the phenomenon of double images. Each eye gave a different image, the difference corresponding to the difference in angle between the two lines of regard. We are not conscious of these images,— their oneness or twoness, or their difference, — but we are conscious of *objects* in relief at a given distance, because we have acquired the power of automatically interpreting the two impressions as being different views of the same object. As in surveying, two readings of an object furnish data for the determination of distance. Relief or depth and volume are secondary aspects of distance.

Convergence. — The turning inward of the two eyes to fixate an object is called convergence and the turning outward to the parallel position, divergence. The angular difference in view from the two eyes is called the binocular parallax. The sensations of these turning movements in this binocular adjustment are an index to distance. Distant objects are seen with the eyes relatively parallel; near objects by more or less convergence.

We can converge the eyes upon only one object at a time. We can, therefore, see clearly only one point at a time in distance. All other points give double images as in Experiment *a*. If we look at one person in the center of an audience, all persons seated nearer to, or farther away from, this person should be seen double. Yet

normally we are not aware of such confusion, largely because we have learned to pay attention to the object we fixate and neglect all confusing impressions; and the eyes normally change rapidly in accommodation and convergence for difference in distances. In rapid movements for differences in distance, we take snapshot focal impressions in the second plane just as in the first. What we see is a summation of focal images, really a composite picture set together in memory.

Briefly in seeing objects in color and space, we are not aware of light waves, nerve impulses, images [1] on the retina, or sensations of eye movements: we see objects directly as we have become acquainted with them through different senses, and as they have meaning to us.

External projection. — This giving of meaning to sensations or automatically registered impressions is well illustrated in the law of external projection: the ray of light is referred back into space along the line of incidence.[2] The bearing of that on the correct perception of objects is self-evident.

[1] In accordance with optical principles the image on the retina is inverted. Professor Stratton wore a pair of prisms in front of his eyes in such a way that everything was seen inverted. He encountered difficulty in eating soup; the bowl hung inverted. In going upstairs the opening of the stairway yawned downward and he had to step upward. After a week he gradually ceased to see things inverted and began to see them as he experienced them before. When he gave up wearing the prisms he had to unlearn the new-found associations, showing that upright vision is purely a matter of association and learning.

[2] The principle of external projection has become so insistent that it operates even for lights that originate within the eye. Wave a wax taper gently at the side of one eye in a darkened room and observe that you will see, as on a screen before you, a rich network. This is the shadow, a true picture of the blood vessels in the retina. Press the eyeball gently on the side and you will see dark moving rings in front of you. These are due to the mere pressure on the eyeball. Squint at the distant sky through the partly closed eyelids of one eye and observe the "floating flakes" and snowball effect. These flakes are the shadows of floating opaque particles in the eye. In all these cases the normal habit of external projection leads us to see these phenomena as outside of the eye in space.

Stereoscopic vision. — Stereoscopic vision furnishes a good confirmation of our explanation of binocular vision. Pictures are flat, but if we take two pictures of the same object at an appropriate angle and carry one view to each eye separately through prisms which make the eye converge, we see relief and perspective, imitating the normal binocular perception of relief.

Vision is, after all, an interpretation of fragmentary visual cues. The more familiar we are with the situation, the less of the cue we need. In normal seeing of objects as well as pictures and print, the interpretation hinges on most slender and inadequate sensory data. The saving feature is that we see things as they ought to be, as we know them to be, or as is reasonable and natural.

Normal Visual Illusions of Space

Things are not what they seem. Nature's sleight of hand furnishes most fascinating instruction and entertainment to him whose mind's eye is open to it; and, in all this bewildering ever presence of error, there is law and order: there is law in illusion. When the illusions are fairly fixed, uniform, and predictable, we call them normal. The study of such normal visual illusions teaches us to predict, explain, enjoy, and correct the distortions of objects as seen, and it throws much light on the nature of the visual process itself. We can here give merely a few illustrations of geometrical illusions of visual space and shall not attempt any complete classification.

Terminal illusions.

EXERCISE. — (*a*) *Place three coins of the same denomination in a row edge to edge. Take out the middle one and slide it over to the right, in the same line, to such a distance that the distance between the middle and the right-hand coin shall seem to be equal to the original distance across the three coins. Measure and record the error in per cent.*

(*b*) *Place the three coins in the first position above and move the middle coin out away from you to such a position that the distance between the adjacent edges of it and each of the other coins shall seem to be equal to the original distance across the three coins. Measure and record the error in per cent.*

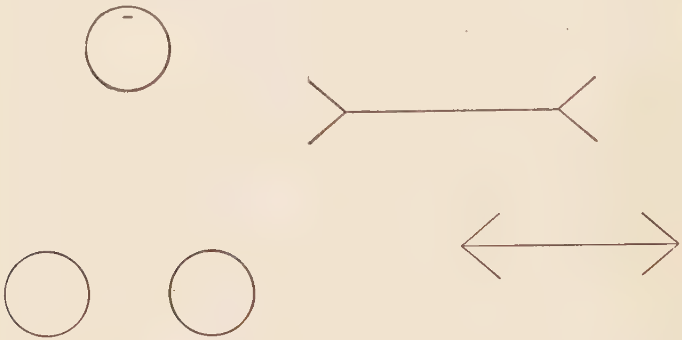
(*c*) *Place two coins in line, pointing away from you so that the distance between them shall seem to be equal to the diameter of one coin. Measure and record the error in per cent.*

The explanation of the terminal illusion involves a complex set of motives of which one may operate in some forms of the figure and another in other forms; often several motives coöperate. In judging linear distances we tend to confuse pure line distance with suggested area of extension. Thus, in the above exercise, the arcs of the coins are the "terminals" of the distance measured: if the terminals turn toward each other, the distance is shortened; if they turn away from each other, the distance is lengthened. This general principle may in turn be traced to specific motives, such as eye movements, irradiation, perspective, or "filled space," which we cannot here stop to explain.

The situation in Experiment *b* is illustrated in Fig. 3, *A*. You probably placed the middle coin in the position here shown; but to be right, it should have been placed above the dot in the circle above. Fig. 3, *B*, illustrates

the same principle, where angle lines are used as terminals. The two base lines are equal, but the lower one seems to be about 13 per cent shorter. The force of the illusion varies with the character of the terminal, which may take a countless variety of forms.

To illustrate the fixed rôle of this illusion in design, look at carpets, napkins, wall papers, dress goods — any-



A B

FIG. 3. — Terminal illusions

where in art and decoration or nature, where linear distances are marked off by terminal objects or forms — and you will see these illusions. It is very interesting to find that in wall paper design, for instance, the artist has taken the illusion into account and made the appropriate correction in order to get such apparent spacing effects as 1 : 1, 1 : 2, or 1 : 1.62 (the golden section). Fig. 4 illustrates this illusion in a design: the distance between the two globelike figures looks equal to the diameter of each of the figures, but is 14 per cent shorter. The artist may not know the quantitative force of the

illusion and may not be aware of its nature, or even its existence; but, in designing, he stands off and sketches to suit his eye and, in so doing, corrects for the illusion. Designs built of two, three, or four unit groups or lines, circles, triangles, or any other form, as in the above exercises, may be of any degree of complexity, but will always embody the illusion. Indeed, the more irregular

FIG. 4. — A terminal illusion

the figure is, the more effective the illusion will be; for this reason the illusion is more effective in the freedom of nature than in the restrictions of geometrical drawings.[1]

Small angle illusions.

EXERCISE. — *(a) Without measuring or using any accessory aid, check the dot that the short slanting line in Fig. 5,* A, *would appear to strike if continued as a straight line to the dotted line. Record number of dot, counting from the bottom.*

(b) Check dot that the slanting base line in Fig. 5, B, *would appear*

[1] It would be very profitable for the class to divide the task and make a rough survey of normal illusions; *e.g.*, in groups of wall paper designs, trees, and art objects.

to strike if continued to the arc above as a straight line. Record number, counting from the left.

Now lay on a straight edge and determine the amount of illusion for each figure.

Small angles are always overestimated. The two cases in the exercise represent two of the fundamental

FIG. 5. — Small angle illusions

types of these illusions which occur in nature and art wherever small angles exist.

The reliable observer will mark the dot about 8 mm. too high in *A*, and about 4 mm. too far to the left in *B*.

The rigidity of this illusion is illustrated in Fig. 6, *A*, which is a square inscribed in a circle. You can see a perfect square with an indented circle or a perfect circle with a caved-in square; you cannot see a perfect circle and a perfect square at the same time. The fact that

the distortion is forced under such rigid conditions of drawings, as in these illustrations, is a most severe test of the principle. In Fig. 6, *B*, the upper right-hand slanting line seems to point the continuation of the upper left slanting line, but the lower is correct.

Association illusions.

EXERCISE. — *Draw a horizontal line of any length and, at the middle of it, erect a vertical line such that it shall seem to be of the same length as the horizontal line. Measure the error. Then draw the line to scale and observe that it does not look right.*

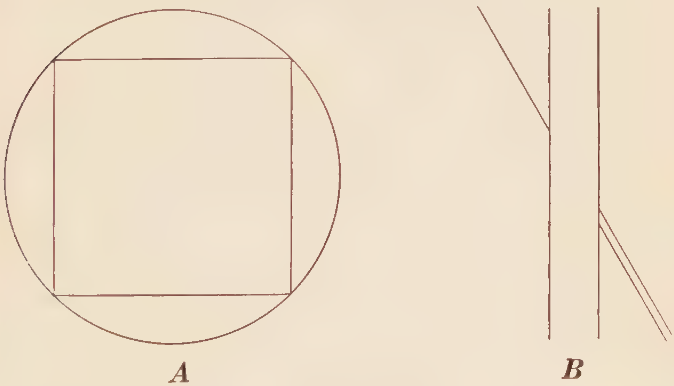


FIG. 6. — Small angle illusions

The very gross constant error in this exercise is due partly to the tendency to compare the vertical line with one-half of the horizontal. The silk hat in Fig. 7, *A*, is a good illustration of the combination of several motives in producing a large illusion. The height of the crown is equal to the smallest diameter; but, on the average, it seems to be about 18 per cent greater. The two segments in Fig. 7, *B*, are of exactly the same shape and size.

Illusion of reversible perspective.

EXERCISE. — *Count the number of blocks in Fig. 8. Record number and characterize difficulties encountered.*

Figs. 8 and 9 are ambiguous:[1] as we look at them "steadily," they suddenly shift and take an entirely different form and position. We have formed the habit of thinking that the first point of an object that catches our eye is the near point; when the figure is ambiguous,

A *B*

FIG. 7. — Association illusions

this determines which of the alternate views we shall see. The eyes are never still for any considerable time; therefore the view should change several times a second. But there is a lag for interpretation in perception, so that probably it seems to change only every few seconds. This illusion of reversible perspective is a specific case of the general law of apperception, as are really all illusions.

General principles of illusions. — Visual illusions may be divided roughly into two classes: those that may be

[1] Fig. 9 was prepared for use in Chapter XXI, but had to be rejected for that purpose because "it would not stand still."

eradicated with practice, and those that may not. Knowledge of the existence of the illusion lessens its force; the force of the illusion has been very much reduced for you in the above exercise on account of the announcement of the illusion. Absence of normal il-

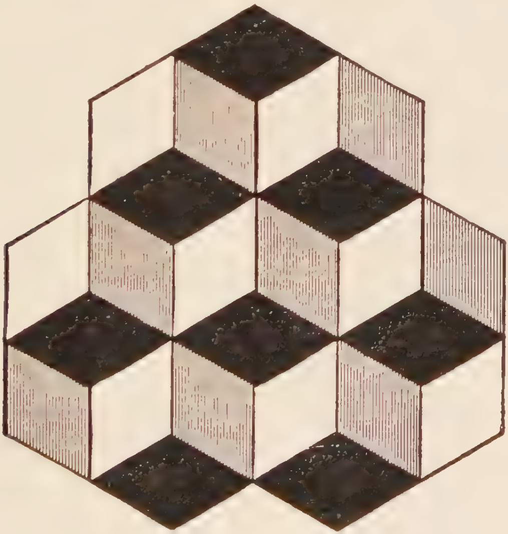


FIG. 8. — Reversible perspective

lusions is not a mark of intelligence: the feebleminded rarely experience normal illusions. It is difficult to distinguish between what we actually see and what we know or guess that we should see. Diminution of the effect of a motive is usually due to the counteraction of opposing motives. Likewise, very large effects are usually due to the coöperation of two or more motives; in a common object we may have five or ten motives, some counteracting, some coöperating as in Fig. 7 *A*.

The lesson from this sampling of illusions should be that there are illusions in all our normal vision, that they occur according to law and order, that knowledge of them enables us to make appropriate allowance, and that a complete understanding of the laws of illusion would be

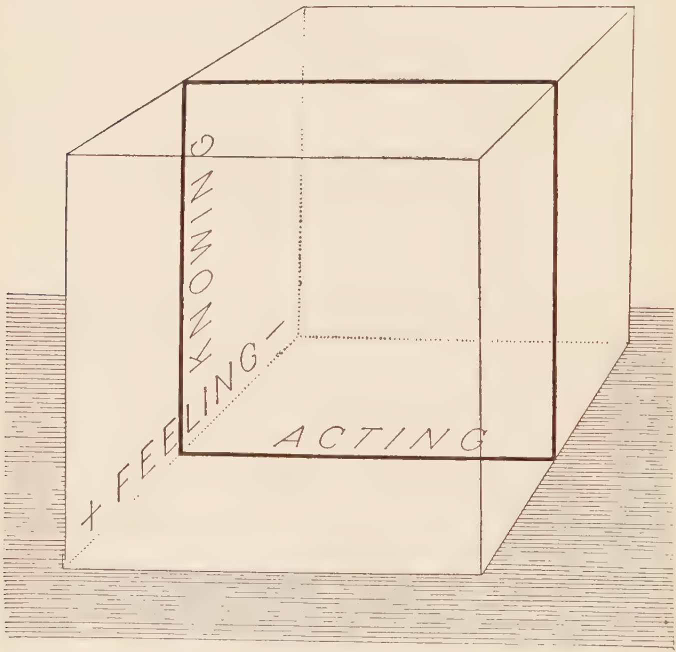


FIG. 9. — Reversible perspective

a complete understanding of the human mind. To see the world with knowledge of these illusions is like visiting a botanical garden with a knowledge of odd traits of plants and flowers — interesting in themselves and necessary for the understanding of the object as a whole.

CHAPTER V

HEARING

HEARING is dominantly the sense of tone and time. All sounds may be described completely in terms of quality, intensity, duration, and extensity of sensation; *i.e.*, pitch, loudness, time, and space in the complex forms of perception. The quality of sound is pitch, which corresponds to the physical vibration frequency. The intensity of sound is loudness, which corresponds to the amplitude or force of vibration. The duration of a sound corresponds to the duration of vibration. Extensity corresponds to the length of the sound wave. From these four elemental aspects of hearing, we derive the complex forms of perception, such as timbre, noise, rhythm, and volume.[1] (For structure of the ear see Appendix, Figs. 31–34.)

PITCH

The nature of pitch. Pitch is the tonal aspect of sound, the essence of what we hear. Intensity, duration, and extensity of sound are only variables of this quality. Timbre and tonal fusion are mere complexes of pitch. Though the vibration is the cause of a tone, we are not ordinarily conscious of vibrations at all: we hear sounds,

[1] The ear is a sensitive mechanism the function of which is to receive, vary, and transmit certain vibrations and to transform these into nerve impulses which are conditioned by the frequency, form, amplitude, and duration of the vibration, and which are the physiological correlates of the attributes of sound sensations; viz., quality, intensity, duration, and extensity.

tone, pitch. This is a marvelous transformation. The organism registers all the intricacies of vibration and, by the magic "from matter to mind," we hear a corresponding wealth in variety of sound in terms of tonal meaning and can make as fine distinctions in tonal hearing as one-fifth of a vibration without being aware of a vibration. Still, for the science of hearing, we must analyze and explain in terms of vibration.

The physiological basis of pitch. — No theory of the anatomy and physiology of the pitch-differentiating mechanism in the ear has been fully established. The harp theory maintains that there is a mechanism in the ear which differentiates pitch; but there are divergent theories as to the location and the mechanism of such harp structure. Early investigators maintained that the basilar membrane serves this purpose; but some physiologists ascribe this function to the tectorial membrane. We have no conclusive proof for either theory, although the support for the basilar membrane theory seems to be the stronger. Possibly there is an element of truth in each theory and the two membranes coöperate. It is thought that the harp structure is capable of being tuned to as many pitches as the human ear can hear; so that, when a particular vibration frequency is conveyed to it by the liquid of the inner ear, a particular segment will vibrate sympathetically because tuned to that frequency, and other parts will remain quiescent. The end-organ of hearing is the spiral layer of hair-cells which is so located that the cells will be physically stimulated by transmitted sound waves. The mechanical vibration at any particular frequency of the harp "strings" pro-

duces a chemical change in a cell, which results in a nerve impulse that is transmitted over a special nerve fiber from that cell to a particular part of the brain.

The ear is a most wonderful mechanism with its membranes, levers, and liquid conductors carrying the vibration to the harp structure, its means of analysis of all pitches in that structure, and its means of transmission of each pitch over its particular line to the brain. For psychological purposes it is necessary to make certain assumptions, of which the essential one is that there is a pitch-differentiating mechanism in the ear which is so organized that it is capable of serving as a physical basis for the sensory phenomena with which we deal in the psychology of hearing; namely, pitch, intensity, timbre, volume, fusion, and consonance, and their derivatives or variants.

The lower limit of pitch. — Vibrations must reach a certain frequency before they can form a tone. Under most favorable conditions, with a special tuning-fork, twelve vibrations per second may be heard as a tone, although the individual puffs may be heard as pulsations in the tone up to twenty vibrations, or higher. This lowest tone, which may be produced only momentarily, is, of course, very deep and seems massive and rolling in the distance. The lower limit depends upon the form and force of the vibration as determined by the shape, position, and swing of the sounding body. Waves from electrical sparks, *e.g.*, do not fuse into a tone below 100 vibrations per second.

The upper limit of pitch. — There is likewise an upper limit of tonality, set by the limits in the harp structure

in the ear. Experiments now indicate that the upper limit is probably not far from 30,000 d.v. (double vibrations per second).[1] This upper limit varies greatly with age and with individuals of the same age. Roughly, it may be said that, if the upper limit is 30,000 d.v. for a person of seventeen, it is quite probable that it will be reduced to 15,000 d.v. by the age of seventy. This decline results not only in the loss of high tones but also in radical changes in the character of low tones through the loss of their high overtones. This decrease with age seems to be quite independent of the use of the ear. It is undoubtedly in accord with the biological law that the most delicate structures are the first to suffer decline with increasing callousness from age.

Pitch discrimination. — The fundamental measure of capacity for tonal hearing is called pitch discrimination and is expressed in terms of the least perceptible difference (l.p.d.) in pitch in terms of vibrations. It may be measured accurately with a set of tuning-forks tuned for convenient differences in pitch.[2] This measure of pitch discrimination or sense of pitch becomes a sort of yardstick in terms of which we measure a great variety of tonal features. One of the most practical applications lies in the measurement of individual differences for tonal hearing. Some persons cannot recognize the tune of Yankee Doodle except by the words. Some normal ears are not sensitive to smaller differences in pitch than a half-tone. Others may hear perfectly differences as

[1] 25000 d.v. is the highest limit yet reached experimentally because it is difficult to get high tones sufficiently loud.

[2] Columbia phonograph record No. 7536, "The Sense of Pitch," is serviceable for this measurement.

small as $\frac{1}{200}$ of a tone. The latter, then, are at least one hundred times as keen as the former.

Pitch discrimination as a physiological capacity does not vary with age, except in so far as deterioration may set in. The child may reach his finest use of the sense of pitch during the first year or two. Knowledge about pitch and ability to designate it of course comes later. The differences we find indicated for various ages in practical testing are fully accounted for by the difference in knowledge of pitch and the power of attention in application to the task. There is no significant variation with sex, and perhaps no great variation with race.

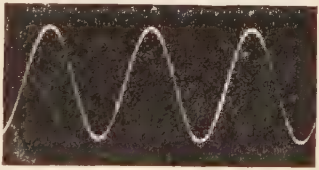


FIG. 10. — Tracing from a tuning-fork

Pitch discrimination does not vary with training. In this respect the ear is like the eye. No amount of training will improve the visual acuity of the eye as an organ. Visual training results in learning how to use the acuity to the limit of the capacity of the organism. So in hearing, the harp structure in the ear is probably at its best early in infancy, and change in capacity is likely to be in the direction of deterioration. But this does not discourage ear training in education. From infancy to the most extreme and refined art-training in music, there is unlimited opportunity for development of hearing. But this is not improving the ear or the psychophysic capacity for pitch discrimination: it is merely the development of the meaning and skill in the use of a delicate organ.

Pitch discrimination does not vary with intelligence. A person may be the ablest mathematician or philosopher and not have the gift of a good sense of pitch ; and, contrariwise, it is notorious that musical prodigies, as far as tonal hearing is concerned, have often been of low wit. On the other hand, pitch discrimination is a tool of thought. No man can image, think, feel, or control tonal effects which he has not heard.

In music, the discovery of extraordinary talent and the direction and encouragement of talent is a problem involving not only happiness and success, but economic and moral problems. There are many other occupations in which life depends upon tonal hearing. Thus in the World War it was quite possible to select by means of tests of pitch discrimination from a group of ten equally trained cadets one who, by virtue of his fine hearing, could locate a submarine from two to ten times as accurately as another. And, between music and war lies many a fertile field.

Timbre. — A tone is said to be pure when it is caused by a simple, uniform, smooth, pendular vibration, as in Fig. 10, which is a tracing from a point of a vibrating tuning-fork when drawn evenly across a sensitive paper. Pure tones are rare in nature and are not much used in music, partly because they are thin and colorless, and partly because it is difficult to produce them. Tones which are not pure are rich in varying degrees. The various degrees and kinds of richness we call timbre.[1] We explain timbre in terms of overtones as illustrated

[1] In common language, physics, and music, the term quality is ordinarily used to designate timbre, but psychologically this is incorrect, as has been shown above.

in Fig. 11, where the form of the upper wave is determined by, and may be analyzed into, the presence of overtones 2–12. When we hear, *e.g.*, a violin tone, the richness is due to the fact that the string produces not only one tone but a series of tones that blend and fuse into one. When the string is bowed it divides itself into segments, each of which vibrates by itself. The string vibrates by halves, thirds, fourths, etc., up to as many as thirty sections under favorable conditions. Each segment produces a tone of its own to play its part in the ensemble of the clang. From the point of view of physics, these segments are called partials; from the point of view of psychology, the results are called overtones, *i.e.*, tones over the fundamental tone. Tonal timbre may therefore be represented

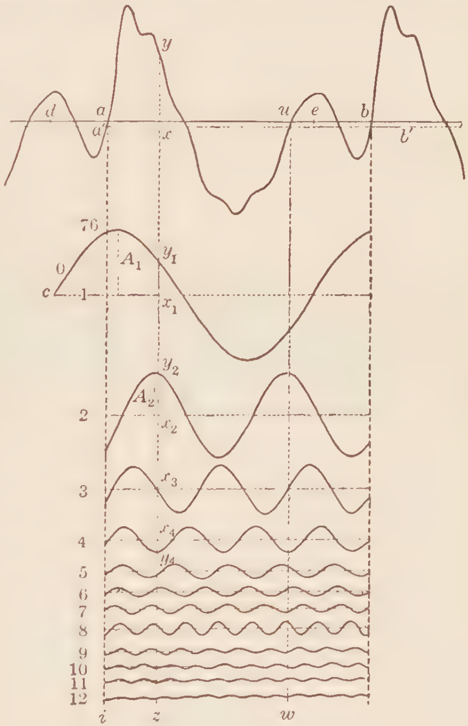
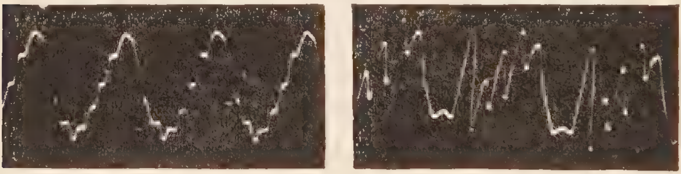


Fig. 11.—A complex sound wave analyzed into its components (Miller)

in terms of wave form as is illustrated in Fig. 12, in which *A* is a photograph of the sound wave from the violin, and *B* from the oboe.

Timbre, then, covers all those tone characteristics which range through the practically infinite variety of pitch complexes in a pure tone at one extreme, through all the degrees of musical richness of tone, to the noise or toneless sound at the other. Thus one piano, one violin, one voice, one noise, differs from another in the timbre. Even the difference between vowels is primarily a matter of timbre — a difference in the number and



A — Violin *B* — Oboe

FIG. 12. — Forms of sound wave (Miller)

relative reinforcement of overtones. We shall be helped in our orientation in this field if we keep clearly in mind two concepts: first, that, psychologically, timbre is to be understood and explained as a complex of pitches fused into a single tone; and, second, that, physically, timbre is expressed in terms of the form of a sound wave.

Noise. — We are now prepared to understand the nature of noise. Noise is sound which is so irregular in the form of wave as to make the harshness more conspicuous than the tonality. Noises are produced through the same end-organs as tones. Most noises have an ele-

ment of tonality; tap the pencil on a table, the floor, or a book and each noise will have a recognized pitch. Indeed, practically all the noises of nature are tonal.[1] Likewise, it is true that most of the tones of nature and of art, including the human voice, carry accessory noises. Indeed, good music seems to demand cymbals, drums, and kettles to supplement relatively pure and mellow tones.

Noises are classified into simple and complex. A rap, a tap, a flick, a thud, are examples of simple noises of which there are a vast variety in nature. But all nature is anoise with complex sounds, such as rattle, patter, purling, buzz, whirr, and whining. Indeed the dictionary contains a surprisingly large number of names for different kinds of noises.

Beats. — We have so far examined a single tone in its various degrees of complexity. It is only a further step in the same direction to explain the experience of simultaneous tones, as in consonance and dissonance, which are the elemental forms of harmony and discord. If we take a series of forks and sound, *e.g.*, 435 and 436 d.v., there will be a pronounced beat or swell in loudness once a second; for 435 and 437, it will be twice a second, and so on, the rule being that there will be as many beats per second as the number of vibrations of difference per second. This is due to the physical principle of interference: when the waves are in the same phase, they cooperate and the sound is loud; when they are in the

[1] Carlyle says: "See deep enough and you see musically; the heart of nature being everywhere music if you can only reach it."

Byron says: "There's music in the sighing of a reed:
There's music in the gushing of a rill:
There's music in all things if men had ears."

opposite phase, they counteract and the sound nearly ceases.

Combination tones. — When the beats cease to be heard as beats, they suddenly appear as a new phantom tone known as a difference tone. Thus c^1, 256 d.v., and e^1, 320 d.v., will be heard not only as these two tones or a blend, when sounded together, but there will be heard also a low tone corresponding to the difference in pitch, *i.e.*, 64 d.v. Likewise, a summation tone is produced, corresponding always to a pitch denoted by the sum of the two vibration frequencies, as in the case of c^1 and e^1 above, where the first difference tone is 64 d.v., the summation tone is 576 d.v. These combination tones play an important rôle in richness and blending of chords.

Consonance and dissonance. — When two tones are sounded together, we speak of a two-clang; when the two tones blend and tend to agree and fuse into one tone, the two-clang is said to be consonant.[1] The opposite is dissonance. Between extreme consonance and extreme dissonance we have a gradual transition. In music we speak of consonances, semi-consonances, and dissonances. Furthermore, there are different kinds of consonances and dissonances. In general, the octave forms a unit, and the various consonances and dissonances are repeated in all other octaves. When two or more notes of the same pitch are sounded together, they are heard as one, and this one is located in some false position according to the physical law of the resultant of forces

[1] The "sense of consonance" may be measured with Columbia phonograph record No. 7439.

and is known as a phantom sound. We must not confuse consonance and dissonance with agreeableness and disagreeableness in music; in general we like consonance, but sometimes we may be in a mood that is agreeably vented in discord, and discord is essential for many pleasing musical effects.

Harmony and discord. — Thus, we have reviewed the conditions which determine harmony and discord of sounds. When two or more sounds are produced simultaneously, the fusion is characterized by two features: (1) the richness of the fusion depends upon the timbre of each source, the presence of difference tones, summation tones, and the consonance-dissonance relations of all tones; and (2) the unity of the experience is determined by the fusion of all tones of the same pitch, by the massive blend of consonances, and by the fusion of overtones with the fundamental.

Melody. — Melody is essentially a pleasing sequence of tones. In many ways, the laws of consonance apply to melody, as in harmony.

Intensity of Sound

Hearing-ability, technically called acuity of hearing, is measured in terms of the faintest sound that can be heard; *i.e.*, the threshold of hearing, by means of some form of audiometer. This threshold varies for ears from the keenest to the deaf. Acuity varies also for different pitches. A thorough test must, therefore, cover all tones within the significant range of pitch. Some persons have tonal gaps in the form of a small range of pitch for which they do not hear sounds; others are limited

to a small "island" of hearing. Many so-called deaf have islands in which they can hear for a limited range of pitch. The significance of knowledge about this is of course patent for schools, many industrial occupations, and for art.

Variation in intensity plays an important rôle in hearing. All musical "expression" rests largely on intensity; *i.e.*, "hearing" loudness differences, and their control by hearing. Next to pitch inflection, the graceful nuances of the human speech are variations in intensity. The hearing of direction, distance, and volume of all sounds is largely a matter of hearing of intensity differences. Discrimination for intensity in terms of the least perceptible difference is measured by means of an audiometer, in which the loudness of a given tone or noise may be controlled and measured.[1]

A blind person may walk about the streets and guide himself largely by hearing. The blind as a class are no more sensitive to sound than seeing persons, nor are they necessarily keener in discrimination. The difference lies in the fact that they have learned to use their auditory discrimination as a substitute for sight. The same is true of artists in music. They have learned to attach meaning to delicate shades of intensity differences.

The Sense of Time

The motor theory. — While we perceive time more or less directly through the various senses, hearing is pre-

[1] To measure this, use Columbia phonograph record No. 7537, "The Sense of Intensity."

eminently the sense of time. We must distinguish this, however, from the general estimation, or the flow of time, as in hours, days, or years. In noting the duration of a single sound, we have a tendency to reproduce it actually, inceptively, or by mere image of action. Likewise, in judging a succession of sensations of sound, we match the duration of intervals with the time we are "keeping" subjectively. The movements need not be sound-producing: they may be any kind from a twitch of the eye to the twitch of a toe.

Time discrimination. — "Auditory time" is limited to the perception of short duration of intervals, periodicity, and time in rhythm. Like the sense of pitch, the sense of time is a talent. Each person has a personal equation expressing his natural aptitude in this respect. This is measured in terms of the least perceptible difference in time.[1] A person of rare capacity may hear a variation of $\frac{1}{100}$ sec., while another may not hear a variation of $\frac{50}{100}$ sec. in a standard rate of 1 second; *i.e.*, one is fifty times as keen as another and this difference may be a relatively fixed trait.

Subjective rhythm.

Exercise. — *Listen to the tick of a pendulum clock or metronome and observe the inceptive movements to mark the time. Describe the tendencies you observe. Now, tilt the clock so as to make it limp and state how you can tell that one interval is longer than the other.*

The hearing of rhythm. — The sense of rhythm is an instinctive disposition to group recurrent sense impressions vividly and with precision by time, or intensity,

[1] To measure this, use Columbia phonograph record No. 7538, "The Sense of Time."

or both, in such a way as to derive pleasure and efficiency through the grouping.

Rhythm as heard may be either subjective or objective. The objective rhythm, as we ordinarily find it in prose and poetry, is marked by emphasis of time, or intensity, or both. Occasionally it may be also through pitch, although that always involves intensity. It is probable that it may also come through other senses than hearing. Subjective rhythm is more fundamental than objective rhythm and always plays a large rôle in the objective. This is the reason why we find rhythm more essentially a matter of personality rather than a matter of objective grouping. All rhythm is primarily a projection of personality. The rhythm is what I am. For him who is not endowed with this talent, the objective workings of rhythm in nature and art are largely wasted.

Subjective rhythm is the grouping of tones or time intervals which are absolutely uniform in time and intensity, quite as though certain of the notes were actually accented. This is a universal tendency which may easily be verified. If, for example, a series of tones of absolute uniformity in every respect be played, the listener will inevitably hear time in measures; for example, $\frac{2}{4}$ or $\frac{3}{4}$ time, and will actually hear the appropriate notes accented.

While the perception of rhythm involves the whole organism, it requires primarily five fundamental capacities. The first two of these are the sense of time and the sense of intensity, corresponding respectively to the two attributes of sound which constitute the sen-

sory media of rhythm. The third and fourth are auditory imagery and motor imagery; that is, the capacity for reliving vividly in representation the auditory experience and the motor attitudes respectively. The fifth is a motor impulse for rhythm in action, an instinctive tendency chiefly unconscious and largely organic. These five factors may be said to be basic to the sense of rhythm. Other general factors, such as emotional type and temperament, logical span, or creative imagination, are intimately woven into the warp and woof of rhythm, but we shall probably find that these are secondary to the primary and basic forces named.

There are two fundamental traits of rhythmic perception; namely, vividness and precision. A person may have effusive rhythmic feeling in the perception of music and live himself into it realistically and yet not have any capacity for precision. Likewise, one may have fine capacity for precision in rhythmic perception and yet not have the vivid emotional experience of the rhythm. Between these extremes we have many types of rhythmic hearing, both qualitatively and quantitatively.

Auditory Space

Hearing is a specific spatial sense for the hearing of direction, which is an element of the first dimension of space. Other aspects of spatial hearing, such as distance, are more or less secondary or derived. Just as we have two eyes for the perception of distance (second dimension), so we have two ears for the perception of direction (first dimension). Bigness, or extensity, is an inherent attribute in the sensation of sound.

Hearing direction.

EXERCISE. — (*a*) *Be seated, blindfolded, and have some one stand three feet in front and produce a sound, such as the snapping of two coins together, first in front and then a small distance either to the right or to the left, and find out how small a difference in direction you can hear. A good observer will be able to hear a difference of 1° in horizontal direction. Record twenty trials.*

(*b*) *In the same manner, produce the sound in the median plane and ask the observer to point in the direction of the source of sound. Record twenty trials. Compare the result in the two planes.*

We have three sets of mechanisms for the hearing of direction: (1) two ears in symmetrical position; (2) ear funnels; and (3) recesses and shelves in the outer ear. These bring about in turn the three marks of direction, binaural balance of intensity, monaural gradation of intensity, and characteristics of timbre, as follows:

(1) *Binaural intensity.* — When the source of sound is directly to the right, it sounds loudest in the right ear. As we move it forward on the arc of a circle at the level of the ear, it grows gradually weaker in the right and stronger in the left until we reach the front, when the two intensities are equal. The same principle may be traced through the other three quadrants; likewise, through any circles that have the aural axis as a diameter. This difference in intensity is the mark of direction. Ordinarily we are not conscious of intensity differences. What we are aware of hearing is not intensity difference but direction.[1]

[1] A crucial proof of this law lies in the fact that when this principle does not operate we do not hear direction. The median plane, *i.e.*, a plane through the head at right angles to the aural axis, is a case in point, as was demonstrated in Ex. *b*. While we have keen ability for discrimination of right and left from this plane, we have no capacity for hearing direction radially within that plane.

(2) *Monaural intensity.* — But the person with one ear can hear direction surprisingly well, especially on the good ear side. This is due mainly to the intensity difference caused by the funnel; a sound is loudest directly in front of the funnel. From this point it gradually decreases through a semicircle on any radius from the ear to the opposite side 180° away.

(3) *Timbre.* — The outer human ear is "corrugated"; *i.e.*, it has a series of shelves and recesses which break up the rich sounds, reinforcing certain overtones and limiting others on the principle of reflection and refraction of the sounds so that the sound is different according as it comes from one direction or another.[1]

Hearing distance, relief, and volume. — Distance we hear inadequately chiefly in terms of intensity. Hearing gives us no adequate perception of form or relief, as perceived through secondary criteria. Volume may be of different kinds. Thus we have extensity-volume, which varies with pitch and extensity of tone, as may be observed in the comparison of high tones with low tones; intensity-volume, depending entirely on the amplitude of the sound wave; timbre-volume, in which the volume varies with the richness of the tone; and reduplication volume, as when two or more sounds are heard together.

Sounds within that plane may seem to come from any direction within the plane. We cannot distinguish front from back or up from down. This is because the intensity is the same for the two ears for all points within that plane. It is interesting to find that we have a distinct illusion to the effect that we hear direction in this plane and feel considerable confidence in our judgment.

[1] Nature has adopted two types of ear: the movable form as found in the mule and the rabbit, and the stationary timbre-analyzing ear, as in man. Instead of the human ear being a dwarfing of a long ear, as many books say, it is a different kind of ear and is better.

CHAPTER VI

TASTE AND SMELL

TASTE[1]

TASTE is the guardian of the digestive system. Our preliminary sorting of what is fit or unfit, agreeable or disagreeable, for the system is ordinarily done by sight, pressure, smell, and temperature; but taste is the final court of appeal. This censorship is, however, only the restrictive or negative aspect of the function of taste. Its positive, aggressive, and most fundamental function in the biological economy lies in its stimulating effect. This takes two forms: (1) automatic control of the processes of secretion, which is essential to digestion; and (2) a source of pleasure — perhaps the most universal source of pleasure in animal life — the foundation of the will to live.[2]

[1] "Developing as one of the earliest forms of sensitiveness, intimately associated with the vital processes of life and growth, affording manifold richness of pleasure and aversion, full of paradoxical surprises and puzzling problems, and figuratively expressing one of the rarest of human qualities, 'the sense of taste,' constitutes one of man's most interesting contacts with the outer world." (Hollingworth and Poffenberger)

[2] **Taste and digestion.** — Interesting experiments by surgical and physiological methods have demonstrated the truth of the adage, "Good digestion waits on appetite." Agreeable taste initiates the secretion of the gastric juices so that the stomach shall be prepared to perform its chemical processes when the food arrives: indifferent tastes do not effectively release these secretions; offensive tastes may set up negative or defensive reactions. The secretion varies with the palatability of the food. The special appeal to taste by the dessert is a device to stimulate the gastric secretions to a final spurt. As the eye so effectively directs the adjustment of our muscles in walking, so the sense of taste gives initial direction to the whole series of the digestive processes.

The qualities of taste. — How many tastes have we, and what are they? When we think of the vast, almost chaotic, varieties of taste experiences, this question seems difficult to answer; but the reply is quite simple: we have four tastes — four and only four — sweet, sour, salt, and bitter. With these four qualities we can account for all kinds of taste experiences and explain them fully in terms of the following variables: (1) variation of each of the four tastes by itself in intensity, duration, and extensity; (2) variation in the combination of the four tastes in all possible proportions of quality, intensity, duration, and space; (3) variation in the combination of all these varieties in combination with other senses; and (4) the combination of those effective experiences which are commonly regarded as taste, but are not taste at all. The first of these two sets of varieties are self-explanatory; the third and fourth deserve further account.

Taste fusions. — It has been said that before we attempt to explain anything we must attempt to explain it away. The problem of taste blends or fusions is a good case in point. Let us consider some concrete examples.

Case I. — If we take coffee, tea, and quinine and reduce them to the same temperature and the same strength, and draw off the grounds, then blindfold the

The joy of eating. — As the eye feasts on color, and the ear on tone, so the mouth feasts on taste. The biological significance of this lies not primarily in the fact that "flavor" is the plastic medium of the most universal art — the art of feeding — but the fact that as color in nature enriches the world without, so savor in the mouth is the most sentient source of the consciousness of the wealth and power of the organism within. In other words, the function of being a guardian and a regulator of digestion is of a rather menial order as compared with that of being the herald of well-being.

observer, plug his nostrils, and with a teaspoon give him a series of drinks out of each cup and require him to name what he is drinking, he will be unable to do so, because under these conditions coffee, tea, and quinine taste alike. They all taste bitter — the same kind of bitter, and nothing but bitter. No one can distinguish them by the quality of taste alone. The best distinguishing mark of coffee and tea is odor; color helps. But quinine has no odor. As quinine is usually taken its distinguishing mark is the intensity of taste.[1] Eliminate odor, color, pressure, and temperature, and keep the three attributes of intensity, duration, and space constant, and these three substances taste alike.[2] It is necessary to proceed slowly and rinse the mouth frequently with distilled water. The conditions must be such that the observer has no sense but taste to judge by, and the tastes are reduced to the same strength.

Case II. — If we take some pure vinegar and some pure dry (sour) wine, dilute the vinegar to the same strength of sour as the wine, eliminate other senses by taking the same precautions in limiting the sensation to taste as before, and serve the observer a teaspoonful at a time of each liquid for a number of times, and require him to say in each case whether he drank wine or vinegar, under these conditions, wine and vinegar will taste exactly alike: he will not be able to distinguish

[1] In the original experiment as performed by Patrick, one of the observers was anosmic, completely devoid of the sense of smell. Normal observers find some difficulty in eliminating smell by means of plugging the nostrils.

[2] The wag may query, "If odor is the common source of pleasure in coffee and tea, why not just sit down and smell the coffee and tea?" Or, "If you want to taste a hot liquid, why not drink a cup of a solution of quinine?" The answer is clear: we enjoy coffee and tea through several senses, and the basic motive for drinking them is the stimulating after-effect, which is quite independent of taste.

them. The "bouquet" or flavor of the wine is its odor. The merit of vinegar is its strength and purity. Dry wine and vinegar have the same taste — sour, and when pure, nothing but sour.

Case III. — If we take honey, various kinds of syrup, sugar, and molasses, reduce them to the same degree of sweetness, eliminate all other senses except taste and serve as before, the observer will not be able to distinguish any of these by taste. They all taste the same — sweet, and when pure, nothing but sweet. The relish of one more than another is in terms of sensation of color and complicated associations and instinctive tendencies.

Case IV. — If we take all obtainable samples of fresh meat, — beef, mutton, pork (fibrous), turkey, chicken, quail, duck, etc.; boil each of them without seasoning, reduce to a fine pulp, eliminate other senses than taste, and serve them with appropriate precaution, all these meats (fresh) will taste alike. They have a delicate taste of sweetness, and that alone. No one can tell pork from turkey or venison from quail, by taste.[1]

[1] The "taste" of meats as we know them resolves itself to a muscular strain, odor, color, and form, with a sweet taste, and, most of all, the taste of the seasoning and accessories in serving. The experimenter, when asked "Why is turkey preferred to chicken?" replied, "Because there is more of it." "Why, then, is quail better than chicken?" "Because there is less of it." This paradox should help us in our analysis of the perception of taste. The taste of turkey is exactly the same as the taste of chicken. But the trouble is that the chicken does not have a fair chance. We serve turkey when we are to have guests or on holidays to celebrate. We dress up, take leisure, invite our best friends, decorate with flowers, use our best table service, and accompany the eating with music. And in preparation for all this, the cook has taxed her culinary art to prepare the most delicate dressing, to "perfection" to roast, and garnish, and finally to have it carried in in state, the center of the feast, playing upon all the senses, imagination, and feeling. Our mouths water and the turkey tastes good. All this is unfair to the chicken.

Take the other paradox; Why is quail preferred to chicken? "Because

Countless experiments similar to these four might be arranged to aid in the analysis. The point is clear that what we ordinarily think of as taste often is admixtures from other senses or is dominated by associations or feelings. What we shall taste is not a matter of sensation but a rich setting in instinctive responses and their fixed associations.[1]

The sense organs of taste. — The taste buds or flasks (Appendix, Fig. 35) lie in little nodules, folds, or ridges, called papillae in the surface of the tongue and adjacent areas of the mouth. These flasks contain the taste cells, each of which has a hairlike projection in the neck of the flask serving as a wick. The nerve of taste branches around these cells. The saliva aids in depositing a solution from the tastable substances. The movement of the tongue acts as a churning process, and forces the solution through the pores. The chemical action in the taste cells sets up a nervous impulse which is carried to the brain. To what extent these taste

there is less of it." Suppose that father has been trudging through the thick underbrush for many hours and finally comes home to his family of eight with one lone quail in his bag. The taste of that bird will be heightened in proportion to its littleness, in comparison with the labor it has cost; also by the knowledge that it is rare. With this also comes an instinctive appreciation for hunting game in the wild. Chicken is tame.

[1] **Taste of an anosmic**. One of the observers in the original experiment by Patrick was anosmic; *i.e.*, she was completely devoid of the sense of smell. The theory of the experiment was that those substances which normal observers can, but the anosmic cannot, recognize when blindfolded are recognizable primarily by their odor, and not by their taste. Among these are tincture of vanilla, vanilla extract, spirits of almond, pineapple syrup, orange, lemon, banana, grape, quince, strawberry, fig, tea, cocoa, chocolate, milk, sour milk, vinegar, claret, oil of rose, rhubarb, onion, boiled turnip, navy beans (liquid form), liquor of raw oysters, yolk of egg, white of egg, kerosene, peach syrup, currant jelly, wintergreen, port wine, sherry wine, brandy, unsalted butter, cream, olive oil, vaseline, cabbage, pumpkin, raw potato, beef broth, mutton, and mutton broth. A similar list could be made for each of the other taste-supporting senses.

cells are specialized for the respective tastes we do not know. The tip of the tongue is primarily sensitive to sweetness, the top near the root to bitter, the sides to sour, and the larger part of the surface to salt. Two or more tastes may be obtained from the same papilla.

Combinations of taste. — Taste qualities do not mix to form intermediate tastes as do colors and tones. They behave like four independent series. Indeed, some think sweet is as different from sour as sweet from cold. We cannot pass gradually from one taste into another. Yet the effect of one taste upon another is a matter of common observation. The edge of one taste may be taken off (compensation or neutralization) by another, as acid by sugar in lemonade. On account of the apparent mixture, it often becomes difficult to say whether a certain combination is sweet or bitter though clearly tastable. Under certain conditions tastes contrast with one another. But of this we know very little. It is probable that many of the effects are associational rather than sensory.

Individual differences. — From the point of view of intensity of sensations, we have the two problems of sensitivity and discrimination as in other senses. These may be measured by using appropriate solutions of salt, acid, sugar, and quinine. There are very great individual differences both in sensitivity and discrimination, from that of the most delicate response to taste differences in the connoisseur, to ageusia, the loss of the sense of taste for one or more of the four qualities.

Lag and latent time. — From the point of view of duration of taste, we are interested in two classes of

phenomena: (1) lag and latent time, and (2) adaptation and fatigue. Taste is the slowest of all the senses. It has to await chemical analysis. The time that elapses between the beginning of the stimulation and the beginning of the sensation is called latent time. This is three times as long for bitter as for salt, as is shown in the typical reaction-time to taste: salt, .30 sec., sour, .55 sec., and bitter, 1.20 sec. Likewise, taste persists longer than other senses, partly on account of the lingering of the stimulus. This persistence is called the lag of the sensation.

Adaptation, fatigue, and habituation. — Like the ear, the eye, and the nostril, the tongue does not adapt itself to the stimulus to a marked degree. As a physiological organism it is strong and stable. It does, however, like all the other senses, respond to habituation and organic adaptation to use. The strong and unpleasant may become mild and agreeable, as in habituation to tobacco and drinks; the moderate and agreeable may become strong and disagreeable. These adaptations are undoubtedly based upon aggressive or defensive organizations in the physiological mechanism.

Location of taste. — Is taste a space sense? On account of our manifold of equipment for space perception, and on account of the limited spatial area for taste we may say that taste is not used extensively as a space sense. However, if we take a solution of sugar and another of pure water, and apply to the tongue a drop of each simultaneously in two places on the tongue so that the only difference is location and taste, we will have no difficulty in saying which drop was sweet. Taste has

the same peripheral facilities for space registration in the mouth as touch has. While its sphere is limited, taste may undoubtedly function in giving position and area of tastable substances in the mouth.

Smell

Smell,[1] "taste at a distance," is the guardian of respiration. The original chemical sense perhaps serves both the purposes of taste and smell. The purposes of smell are clearly analogous to those of taste. It gives protection and makes foods and drinks palatable, and reaches out to make the perfume of nature and art play upon our organism with enriching effect. One of its most fundamental biological functions is the attraction of sex.

Exercise. — *List all the names of odors that you can.*

[1] "For some inexplicable reason the sense of smell does not hold the high position it deserves among its sisters. There is something of the fallen angel about it. When it woos us with woodland scents and beguiles us with the fragrance of lovely gardens, it is admitted frankly to our discourse. But when it gives us warning of something noxious in our vicinity, it is treated as if the demon had got the upper hand of the angel, and is relegated to outer darkness, punished for its faithful service. . . . In my experience smell is most important. . . . I doubt if there is any sensation arising from sight more delightful than the odors which filter through sun-warmed, wind-tossed branches, or the tide of scents which swells, subsides, rises again wave on wave, filling the wide world with invisible sweetness. A whiff of the universe makes us dream of worlds we have never seen, recalls in a flash entire epochs of our dearest experience. . . . The sense of smell has told me of a coming storm hours before there was any sign of it visible. . . . I know by smell the kind of house we enter. . . . In the evening quiet there are fewer vibrations than in the daytime, and then I rely more largely upon smell. . . . Smell gives me more idea than touch or taste of the manner in which sight and hearing probably discharge their functions. . . . From exhalations I learn much about people. I know often the work they are engaged in. The odors of wood, iron, paint, and drugs cling to the garments of those that work in them. . . . I have not, indeed, the all-knowing scent of the hound or the wild animal. . . . Nevertheless, human odors are as varied and capable of recognition as hands and faces. The dear odors of those I love are so definite, so unmistakable, that nothing can quite obliterate them." (Helen Keller)

The qualities of odors. — Smell is the only sense for which the qualities have not been isolated.[1] The manifold of smell is perhaps greater than that of taste. But we do not know whether the odor qualities lie in one series as in tones, in two as in sight, in four as in taste, or even more. This is the reason we do not know any names for odors. The list called for above may contain names like these: aromatic, fragrant, nauseating, piercing; faded rose-leaves, beefsteak, cheese; sweet, pungent; agreeable, unpleasant. None of these are the names of odors. Aromatic means essentially that it smells, and is, therefore, usually attributed to spices; beefsteak is the name of one of the countless objects of smell; sweet is a taste; pungent refers to pressure and pain; agreeable is a general term referring to feeling;[2] it seems probable that we shall be able to reduce olfactory qualities to a small number, possibly four or six. Many methods have been employed, all very arduous and not entirely successful, for the solving of this problem. Perhaps the best method, after we have a clue or theory, is the method of fatigue.[3]

[1] Henning (der Geruch, Leipsic, 1916) has proposed a classification on the basis of the chemical constituents of odoriferous substances and has represented odors on a prism with such arbitrary names as fragrant, ethereal, and putrid to designate the respective corners of one end, and spicy, resinous, and burned odors the corners at the other end of the prism. He indicates the relationship of all other odors by points on the intervening planes. If this theory were true, it would mark a great step in advance; but unfortunately it has not yet been satisfactorily developed and verified.

[2] It is astonishing how we have floundered in pharmacology, botany, and literary description for want of names with which to designate specific odors.

[3] The theory of specific energy maintains that each sense quality has its own specific end-organs. If in any way we can interfere with one specific set of end-organs, this should result in the loss of sensibility to all the odors that come through that organ and should not interfere with other organs. It so happens that the sense of smell fatigues quickly. If, for instance, we take

End-organs of smell. — The olfactory cells which are the end-organs of smell lie imbedded in the lining of the mucous membrane of the upper chambers of the nose (Appendix, Fig. 36). The stimulus must be in the form of gas or vapor. Even if we fill the nose with the most odoriflc liquid, we cannot smell it. The organ of smell is, in many orders of the lower animals, the most highly developed part of the nervous system. The olfactory lobe is in some animals as large as the hemispheres, which indicates the relative dominance of the sense of smell in these lower orders.

Complementary odors, antagonism, and compensation. — Smell, being a chemical sense, behaves like color, which is also a chemical sense. The phenomena of antagonism, mixture, and contrast are analogous in the two senses, though less stable and less organized in smell. When we mixed complementary colors, we found that they neutralized each other. This law of complementaries holds also for odors, properly chosen; but since we do not know the olfactory qualities, we cannot have any adequate classification of complementaries. The best that we can do is to name some substances. The following pairs are complementary: musk and oil of bitter almonds; caoutchouc and paraffin; ammonia and acetic acid; volatile oils and iodoform. Being

ammonium sulphide, which has a strong odor, and smell it for a minute or two, the sense-organ will be fatigued and the smell of the ammonium is lost. If we then immediately try other substances, we find that under these circumstances we can smell, *e.g.*, oil of anise and oil of turpentine, but cannot smell sulphureted hydrogen, hydrochloric acid, or bromine. The conclusion is that ammonium sulphide, sulphureted hydrogen, hydrochloric acid, and bromine are sensed through the same specific end-organ, and probably belong to the same quality series. While this procedure is satisfactory as far as it goes, it will take many generations of workers to make an adequate survey.

complementary, they are antagonistic and one may be used to destroy the other. This principle of compensation is employed in many arts. Florists, who must follow certain color schemes in decoration, are able to do so by the fact that they are able to subdue obtruding odors on this principle of compensation.

Mixture and contrast. — When we mix two adjacent, *i.e.*, non-complementary colors, red and yellow, we obtain an intermediate color, orange. The same principle applies in odor. This is, of course, one of the fundamental principles of the perfumer's art. Odors may be built up synthetically. Thus, musk and opium, iodine and camphor, valerianic acid and hyacinth result in true mixtures.

It seems possible that the law of contrast also operates, so that one odor enhances another; but it seems probable that the contrasts which are most prominent in our olfactory experiences are largely of the associational type.

Intensity. — Individuals differ in their capacity for smell both in sensitivity and in discrimination, and in this we find the explanation of many of the idiosyncracies and fascinations which may develop as personal tastes. Sensitivity and discrimination may be measured by means of an olfactometer, which is a device for controlling the amount of the odoriferous substances that enters the nostrils.

Adaptation and fatigue.

EXERCISE. — *Hold a piece of camphor, or any other strong odoriferous substance, close to the nostril for a minute or two and observe that at the end of that time you will not smell it at all. Record experience.*

As we have seen, the end-organs of smell fatigue very quickly. This law of adaptation is a beneficent device to relieve us from the consciousness of odor in the environment after the odor has delivered its message. It is like the alarm clock stopping after we have been awakened. Tanneries, gas plants, garbage wagons, chemical laboratories give no disturbance to those who stay by them. Likewise, the most gorgeous play of odors from nature -- even more gorgeous in display than the colors of nature — do not glare at us continually. Beautiful blends wafted in the woodland air are sensed for a short time, but gradually submerge in the interest of the placid life.

CHAPTER VII

CUTANEOUS, MOTOR, AND STATIC SENSES

Pressure, pain, and temperature spots in the skin.

EXERCISE. — *With the point of a slightly dulled pin touch the skin on your wrist lightly in a number of places and observe that you feel distinct sensations of pain, cold, and pressure at different points, and that there are interlying areas which are insensitive to one or more of these sensibilities. Learn to distinguish these three kinds of sensation critically and to locate the sensitive points for each with minute accuracy.*

Now, mark off an area 10 mm. square on the back of the hand with a light ink line, and divide it into sixteen squares by drawing light cross lines. Make three similar plats in your notebook and label them Pressure, Pain, and Cold respectively.

Then survey each small square in detail with a pin point and map in the charts the location of sensitive spots for the three respective sense qualities.

All forms of cutaneous sensibility may be located in points, spots, or areas. These locations are usually different for each of the three cutaneous senses, and between them lie areas of insensibility.

PRESSURE [1]

Pressure as a quality. — Such terms as touch and feeling are too loose for scientific use. When we use the term touch in psychology, it should be understood

[1] "It is not for me to say whether we see best with the hand or the eye. I only know that the world I see with my fingers is alive, ruddy, and satisfying. Touch brings the blind many sweet certainties which our more fortunate fellows miss, because their sense of touch is uncultivated. . . . There is nothing misty or uncertain about what we can touch. Through the sense of touch I

that it is used in the narrower sense as synonymous with pressure. The quality of the sense of touch is pressure and we have only that one quality. The vast variety of tactual experience may be accounted for in terms of (1) intensity, duration, and extensity of pressure; (2) a blend of pressure with other sensations, such as pain, strain, and temperature, and (3) association of pressure with reflexes, feelings, and other non-sensory experience.

Examples of the first class are variations of pressure with *intensity* — contact in all degrees of pressure; *duration* — all degrees of duration; *extensity* — point contact and all variations in tactual space relations; *intensity* and *extensity* — roughness and smoothness; *duration* and *extensity* — motion. Examples of the second class are variations of the sense of pressure in all its varieties with *strain* — hardness, softness, stickiness; with *pain* — sharpness, bluntness, prick, scratch; with *temperature* — clamminess, wetness.[1] Examples of the third class are itching, tingling, tickling.[2]

The organs of pressure. — The organs of pressure are of three kinds, of which the fundamental types are the spring, the spindle, and the ball. (See Appendix, Fig. 37.) In these the end-organ is protected and the pres-

know the faces of friends, the illimitable variety of straight and curved lines, all surfaces, the exuberance of the soil, the delicate shapes of flowers, the noble forms of trees, and the range of mighty winds. Besides objects, surfaces, and atmospherical changes, I perceive countless vibrations. I derive much knowledge of every-day matter from the jars and jolts which are to be felt everywhere in the house." (Helen Keller)

[1] The perception of wetness may be elicited without liquid; *e.g.*, by flour, wood, or metal, properly adjusted for relative temperatures and pressures.

[2] Tickling is produced by intermittent light pressures. To tickle scientifically, attach a bristle to the end of a prong of a large tuning-fork and let the bristle vibrate against the skin.

sure is modulated to make the response to the sense organ delicate. Thus, in the spring type, the Pacinian corpuscle, the nerve ending runs in a cross-section through the layers of springs in the onion-like structure; in the spindle type, the nerve ending is so wound around the spindle that pressure on the spindle stretches the nerve; in the ball type, the nerve ending lies in a pile under the ball. All are mechanical contrivances for adapting the coarse external pressures to the delicate nerve endings. Pressure organs are found in all the linings of the body both external and internal. The skin is sensitive only in spots, as was demonstrated in the exercise. These spots are the locations of the end-organs. Density of the distribution varies with the importance of the sense for a given surface. Considerable areas, *e.g.*, on the back, are but sparsely supplied with end-organs of pressure, and are, therefore, correspondingly insensitive to touch.

In pressure, as in the other senses, the principle of adaptation is one of our blessings. Put a nickel in the palm of the hand and hold the hand perfectly still for two minutes; at the end of that time you will not feel the weight of the nickel. It is this principle of adaptation which enables us to wear hat, coat, and shoes, and to stand on our feet and to lie in bed, all the time pressing on an area of the skin without feeling discomfort. Pressure gives its signal and then withdraws into modest unobtrusiveness.

Sensitivity and discrimination.

EXERCISE. — *Take a hair one inch long from your own head and lay it on a mirror. Lay sheets of smooth writing paper over it*

and find through how many sheets you can locate the hair correctly with the finger tip. Record results.

A good observer can locate a hair through 30 to 50 sheets of twenty-pound bond paper. The surprising keenness shown in the above exercise is very suggestive of our unusual resources. Most of us have a very inadequate conception of our reserve resources. Like smell, touch has remarkable capacity in reserve. The blind furnish a good example. Measurements show that the blind who are able to read raised print with their finger tips almost as fast as we read with our eyes are on the average no more sensitive to touch than we seeing people are. But they have learned to use the tactile sensations by couching meaning in them. The development of this power has not increased their sensitiveness to touch. It has given them the power to use effectively the degree of tactile sensitivity that seeing persons possess but have no occasion to use to such an extent.

Sensitivity for pressure may be further measured by an esthesiometer which has a graduated spring with a point 1 mm. in diameter for contact. Discrimination for intensity may be measured in terms of the least perceptible difference in pressure with the same instrument. Both sensitivity and discrimination vary for different parts of the body in accordance with biological needs and show wide variability for different individuals.

Tactile space. — Pressure is perhaps the taproot of the spatial senses and the point of ultimate orientation for each of the other senses. When we are in doubt we say, "Let me feel it." Our first measure of "tactile

space" is in terms of perception of separateness. If the two points of a pair of dividers are set down upon the skin very close together, they will be felt as one. To be felt as two they must be separated a certain distance which we call the two-point discrimination threshold. A list of representative threshold values for various parts of the body in longitudinal direction is shown in the following table:

Tongue-tip	1.1 mm.
Palm side of last phalanx of finger	2.2 mm.
Red part of lips	4.4 mm.
Tip of nose	6.6 mm.
Back of second phalanx of finger	11.0 mm.
Heel	22.0 mm.
Back of hand	30.8 mm.
Forearm	39.6 mm.
Sternum	44.0 mm.
Back of neck	52.8 mm.
Middle of back	66.0 mm.

Temperature

The qualities of temperature. — The sense of temperature is the guardian of the body against injuries from heat and cold; but it is also an indicator of body condition, and, therefore, serves as a source of pleasure and pain within normal limits. There are two qualities, cold and warmth, each probably evoked by a specific sense organ. The sensation of heat is probably produced by the simultaneous stimulation of the cold and the warm spots, or by excessive stimulation of either. It is often accompanied by pain. We, therefore, regard heat as a complex and not an original sense quality. In passing from warm to cold by gradual change in temperature we pass through a zero point which is neutral. This

is the normal temperature of the body, about 37° C., which, of course, varies from time to time in different areas of the surface. Temperature may be excited by stimulation from within or from without. From within we can generate heat by exercise, fever, or any other activity by some part of the organism. From without the adequate stimulus is radiant energy. There is no general agreement as to which of the end-organs in the skin are the end-organs of temperature.

As was shown in the exercise, the skin is not sensitive to cold except in spots and these spots can be stimulated with an object at a neutral temperature, such as a pin. The same is true of the warmth-spots or areas, but these are not so readily observed with a neutral stimulus. We speak of warm areas and cold areas rather than spots because the skin is a conductor and the stimulus spreads over a considerable area. In mapping the temperature areas we use a little point which may be supplied with circulating warm water or cold water at a constant temperature. Physiological contrasts are effective in temperature, and adaptation is very conspicuous, as in quick adjustment to changes in dress and climate.

Pain

Exercise. — *Make a list of as many kinds of pain as you can think of, arranged in so far as possible in some kind of logical grouping.*

Sensation *vs.* feeling. — The fact that we have sensations of pain is a modern discovery. In literature and good language the sensations of pain have been confused with touch as a sensation and with feeling on the

side of emotion. Pain is a special sense, as distinct from pressure as pressure is from cold. The sense of pain differs from the feeling of pain in that it is an elemental experience, that it has specific sense organs, and that it is objectively localized.

Purposes of pain. — The sense of pain is our most faithful and ever present guardian, — one of our greatest blessings. We should be in greater danger from the loss of the sense of pain than from the loss of the sense of sight or hearing. Pain is the common warning of the onset of disease. On account of its persistence, many diseases are erroneously thought of as essentially pain, as in toothache or the various abdominal aches. Although pain is primarily a preventive mechanism, it also serves as a source of pleasure.

The qualities of pain. — While contemporary experimental work has pointed to the existence of different qualities of pain, it seems probable that there is but one pain. We shall then be able to account for all the thousands of varieties of pains and aches which we describe as cutting, piercing, pricking, gnawing, burning, pinching, smarting, boring, shooting, gripping, stabbing, grinding, sharp, dull, lightning, tearing, creeping, throbbing, etc., in terms of our scheme of attributes and blends as in the case of pressure. Thus all known aspects of the pain experience may be accounted for in terms of the variation of the one quality, pain, (1) in all possible combinations of intensity, duration, and extensity of pain itself; (2) all possible blends of pain with other sense qualities, such as pressure, strain, and temperature; and (3) in all perceptual associations of pain with the

higher mental processes, especially imagination, emotion, and action.

End-organs of pain. — The free nerve endings so abundant, especially in all the linings of the body, are probably the end-organs of pain. Pain in the eye or ear, for example, does not come from stimulation of these senses but from the stimulation of the end-organs of pain with which these special sense organs are supplied. It is, therefore, not true, as has often been held, that pain may come from excessive stimulation of any sense organ. Many parts of the body, such as the brain, have no pain end-organ and are, therefore, not sensitive to pain.[1]

Illusions of location. — Pain is a space sense as is shown by the fact that pain points which give no other sensation than pain may be localized quite as accurately as pressure points; and the same is true of a real stimulation. But pain is notoriously subject to normal illusions of location. Thus, we have referred, projected, deflected, associated, and transferred sensations, for all of which the medical books have elaborate charts. Knowledge of these laws of illusion in the location of pains is of great importance in diagnosis of disease, as diagnosis is done more in terms of the location of pain than in terms of any other sign of internal condition. Fig. 13 shows some of the typical locations of illusory pains.

[1] After the brain is once exposed, incisions into the brain tissue may be made freely without causing sensations of pain. Biologically it is very significant that pain may be aroused by any kind of stimulations — mechanical, chemical, electrical, or thermal. These serve as a sort of universal guard. The pain spots vary in density in proportion to the delicacy of the structure that has to be protected. The surface of the eyeball is well protected. Large areas of the back have no pain spots. Individuals vary much in their supply of nerve endings and in their sensitivity to pain.

A pain is said to be *referred* when it is felt as coming from a certain point of the body and is due, not to initiation in that part, but to irradiation somewhere along the nerve trunk leading from the sensed part of the body.

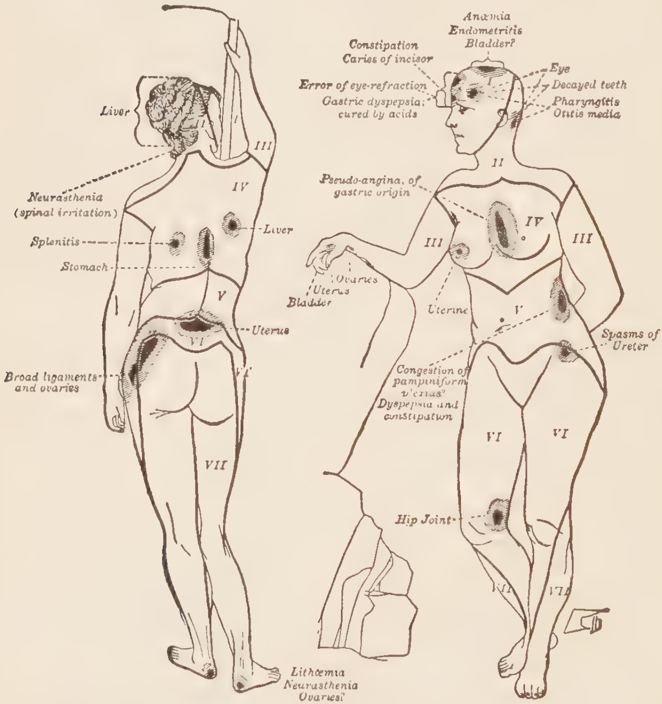


FIG. 13. — The locations of referred pains and their causes (from Herrick after Dana and Starr)

As all the body nerves pass through the spinal cord, injuries to the spinal cord and other large nerve trunks may cause sensations in any part of the body, depending upon what connection has been disturbed; *i.e.*, the

pain is referred to the peripheral ending of the nerve no matter where the stimulus occurs in the course of the nerve. A pain is said to be *projected* when it is felt in a point which is insensitive, as in locomotor ataxia, or in the feeling of pain in an amputated limb. Many people whose limbs are buried feel pain in them. This is clearly related to referred pain, being due to stimulation of the nerve trunk. A pain is said to be *deflected* when the nerve impulse is switched to some other path in transit under pathological conditions. We can easily see how important the charts of these and many other types of normal illusion in the location of pain are for the diagnosis by the physician and how suffering humanity is fooled as to the seats of trouble.

Subjective pain: hallucinations and illusions. — Many of the so-called functional diseases, sometimes most distressing, are due to pressure, inflammation, and other forms of irritation along nerve paths and not to actual injury to tissue in the point felt. Would it not be a relief to the countless sufferers of this type to have scientific knowledge of that fact? Many of the most insistent and painful diseases are like the proverbial black lie, made out of whole cloth — hallucinations. But this does not lessen their severity. The psychology of pain is an important chapter not only in medical diagnosis but also in the treatment of diseases.

Anesthesia and hyperesthesia. — Anesthesia, as in the taking of ether or chloroform, is a loss of sensation due to the effect on the brain and the lowering of consciousness, and may affect one or more than one sense quality. Pain is usually the first to be lost. When

the anesthesia is for pain only, it is called analgesia. This may be central, as in the case of a brain lesion, or the pressure of great fear or joy, or the exaltation which comes from the feeling of power; or it may be peripheral, as in local anesthesia. Hyperesthesia is excessive sensitiveness in any sense. If limited to pain, it is called hyperalgesia.

Pleasure. — Many distinguished authorities maintain that pleasure is a sense complementary to pain. This we deny because there is no special end-organ for pleasure and the experience of pleasure is not elemental, but can be reduced to constituent factors. Pleasure or pleasantness is analogous to unpleasantness. If it were not for the weakness of the word, we should use the term pleasantness consistently in the place of pleasure in psychological terminology. As described elsewhere, we find that pleasantness and unpleasantness, agreeableness and disagreeableness are affective accompaniments not only of sensation but of all mental processes. To say that we have no special sense of pleasure, therefore, does not reduce our recognition of the ever-presence of pleasure in sensory experience. But pleasure is not a special sense nor an attribute of sensation.

Strain.

EXERCISE. — *Eyes closed. (1) Point straight forward and then swing the arm 30° to the right. Record what sensations reported the movement. (2) Hold arm out in any direction. Record what sensations of position you observe. (3) Press finger hard on table. Record what sensations report resistance. (4) Lift book and estimate its weight. Record what sensations report weight.*

The motor senses are now frequently called kinesthetic, meaning energy-sensing. They are also spoken of as the sixth sense and as the muscle sense. They have always been confused with "touch" and "feeling" and often with "effort." The end-organs of the sense of strain are found in the muscles, joints, and tendons. We accordingly speak appropriately of the muscle sense, the tendon sense, and the joint sense. These end-organs are like the end-organs of pressure and work on the same principle as in pressure. Indeed it is difficult to distinguish the resulting sensation from pressure. Perhaps the best figurative way of expressing the difference is to say that the sensation of pressure represents a push and the sensation of strain a pull. They all have the common quality of strain and only one quality. As in related sensations, we may account for all the complex experiences that come through this sense in terms of variation in the three attributes of the strain, through blends with other senses, and through association with higher mental processes.

Purpose. — The purpose of the sense of strain is to furnish information about position and movement of our own body and resistance and weight of other objects. Its significance is recognized when we realize that it is through this sense that practically all our movements, from walking to eating, are reported. Practically all habits of action are conditioned wholly or in part on this sense. Little do we know how dependent we are upon this obscure sense. Think of sitting, standing, walking, eating, writing, driving a nail, singing, sport — indeed all habitual, careful, skilful, careless,

action; think of random movements, reflexes, habits, skill, grace; think of the humblest movements and of the most refined movements as in active sports and the arts and you may realize to some extent the important rôle of this sense.

Position.

EXERCISE. — *Eyes closed, with a pencil held close to the point, make a dot on a sheet of paper. Swing the arm freely in various directions over the paper and then try to put the pencil on the same point. Observe by introspection the nature of your guide and record errors in ten trials.*

Before reaching out to pick up your pencil the eye tells the position of pencil and hand respectively. The position of the hand is also known by the sense of strain. The motor message sent to the muscle directing the movement is based upon position "felt" rather than seen. Think of the enormous amount of data the muscle must have, if we may speak figuratively, to anticipate and direct the correct position of each finger progressively in the grasp. Here sight was an aid and strain played a leading rôle.

Movement.

EXERCISE. — *Make two dots about one inch apart. Put pencil on the right hand dot, and, eyes closed, lift it over to the other dot. Ten trials. Record how you know the extent of the movement.*

Sensation of position is at the basis of sensation of movement, as movement is merely awareness of successive positions and the rate of change. We may speak of arm space, foot space, finger space, according as position, movement, and rate of movement, direction of movement, extent of movement, and distance of move-

ment are reported to us in terms of strain from the respective limbs themselves. We often see objects in anticipation of movement but the movement is guided in detail by the kinesthetic sense. In shaving, *e.g.*, a man looks into the mirror to find his face. He shaves by "touch" and "hand space." Analyze such an act as writing, chewing, or driving a nail, and observe how countless and fine the kinesthetic reports of movements are in guiding these movements. Yet we are so highly organized that the vast mass of them operate with precision without reaching consciousness. The motor senses are at their best when they are automatic.

Resistance. — Beginning with the bare sense of contact, pressure is supplemented by diffuse sensations of strain. This sense of resistance aids us in our adjustment of the force of movement as in grasping, pinching, plucking, biting, treading, hand shaking.

Weight. — Weight is usually felt through active resistance in handling objects. If we analyze the perception of weight of a hat, a teacup, an armful of wood, we find that, while other senses coöperate, it is essentially this sense of strain in resistance that leads to the perception of weight. Even when we merely look at an object we interpret its weight in terms of the motor senses.

The kinesthetic sense is one of the most favorable for exact experimental study. Many laws applicable in other senses have been worked out and established most rigorously in this sense. One of these is Weber's law which was illustrated in vision. Another large group of laws express normal illusions of weight of which the following is an example:

The size-weight illusion.[1]

EXPERIMENT. — *Take an empty but well inflated paper bag in one hand and match its weight with coins, nails, or other metal in the other hand.*[2] *Weigh the bag and the metal and record error.*

If the specific gravity of an object is lower than the central, neutral specific gravity, the weight of that object will be underestimated; whereas if the specific gravity of an object is higher than the neutral specific gravity, the weight of the object will be overestimated.[3] Illusions of this kind occur for all normal persons,[4] and

[1] See Author's "Psychology in Daily Life," Chap. VI, *Law in Illusion.*

[2] These directions will mean nothing at all unless the experiment is actually and carefully performed. It must be experienced to be understood. In place of the paper bag any large, light object, such as a paper box or a down pillow, will do.

[3] For all normal individuals there is in every type of object a given weight which we may call neutral, for which there is no size-weight illusion; all objects like it, but differing in size, are subject to the illusion. In general, objects which are smaller will be overestimated in weight, and objects which are larger will be underestimated. Thus all bouquets are underestimated, and all solid pieces of jewelry are overestimated in weight. Roughly we may classify on the one side relatively light objects, such as feathers, paper, flowers, empty bags, clothes, and hay; and, on the other, relatively heavy objects, such as mercury, solid metals, stone, and perhaps water. Although there are numerous conditions which must be taken into account, and it is by no means a fixed ratio, we may have a rough knowledge of what ordinarily represents a practically neutral size-weight, or specific gravity, by remembering that a solid piece of oak wood comes near being neutral. Books are not far from neutral, though frequently heavier. Dry oak weighs about .65 g. to the cc.; books, .81 g.; and water, 1 g. Letters and clothing are probably lighter. Or, to give a general intimation of the force of the illusion in common objects: if one bottle is seven times the volume of another, but is equal to it in weight and like it except in size, the smaller will seem to be about twice as heavy as the larger. If a ball weighs as much as a "Derby" hat, the ball will seem to weigh about twice as much as the hat. If a man is asked to match the weight of his golf cap with coins, it will be found that the cap actually weighs three or four times as much as the coins laid out in the estimate. In the above experiment, a piece of lead less than one-fifth of the weight of the bag will seem equal to it. Such comparisons as these may be tested in actual experiment by anyone interested.

[4] Normal illusions are like microbes; they are ever present, and they may be beneficent or noxious, but without them mental life as it now is could not exist. Since the discovery of microbes and the discovery of normal illusions, a man

are predictable as to direction and approximate magnitude. Similar experiments might be made to illustrate the conditions of perception of weight. Take a glass of water and observe how its apparent weight changes with the following conditions: (1) position of the glass in various positions within the reach; (2) the force of the grasp in holding; (3) the area of contact, *e.g.*, finger tips or whole hand; (4) rate of lifting; (5) the division of energy in grasping the table with one hand when lifting with the other hand; (6) temperature differences.

Strain a space sense. — As a space sense the sense of strain has a capacity somewhat analogous to that of pressure. It is analogous to hearing in that the space is sensed largely in terms of intensity. We explain several types of visual perception of space in terms of energy of eye-movements. It will also be recalled that the space relation of objects as we see them has come to have its meaning in terms of movement about the object.

Thus, the kinesthetic sense has come to be the corner stone in our spatial construction of the world about us.

EQUILIBRIUM

EXERCISE. — *Seat yourself on a piano stool or swivel office chair and have some one revolve it (1) speeding up slowly, (2) speeding down slowly, (3) keeping a constant speed, and (4) stopping suddenly. Describe in what sense terms you experience the movement. Note also illusions of movement.*

The mechanism of equilibrium. — If we take a rubber tube the size of a pencil, fill it with water, and hold it in

who holds himself free from illusions is like the schoolhouse janitor who indignantly resented the insinuation that there had been microbes in the schoolhouse since he had taken charge of it. He had not seen a single microbe.

a horizontal position and at right angles to the arm at arm's length, the following behavior of the liquid may be observed: turn to the right and the liquid will press against the left end as long as the rate of movement increases; turn at a constant speed and the liquid will remain quiescent; slow up the movement gradually and the liquid will press against the right end of the tube; stop suddenly and the liquid will rebound. Other things being equal, the same principles will operate in any circle around the axis of the arm so that it would be possible to record beginning, acceleration, retardation, and the cessation of the turning in any direction in terms of change of the pressure of the liquid. This is the principle nature has adopted for our sense of equilibrium: it explains the results in the exercise. The device has taken the form of semicircular canals. There are three in each ear, one in each of the three geometrical planes of space. The nerve ending in the sensitive part of each canal registers change of pressure in the plane of that canal. The equilibrium part of the ear is much older than the hearing part. Birds and fish have very highly developed equilibrium organs as compared with the organs of hearing.[1]

[1] As a result of the recent developments in aviation, much attention has been directed to the functioning of the sense of equilibrium. Scientific work is being done, particularly to determine the coöperation of the vestibular system — *i.e.*, the semicircular canals, the utricle, and the saccule in the ear — with other sense organs, in the maintaining of equilibrium in flying. The vestibular system is intimately associated with the eyes, so that disturbance of the ear is quite certain to affect the eye. It is well known that in dizziness the disturbance in vision is very conspicuous. The kinesthetic sense is perhaps even more intimately associated with the vestibular sense in the normal functioning of bodily orientation. Indeed, so far as we experience orientation, it is likely to be in terms of the visual or the kinesthetic sense, and possibly pressure.

Automatic. — Here is an anomaly: the sense organs of equilibrium give us no specific sensations. The perceptions of equilibrium, or loss of equilibrium, are couched mainly in terms of strain and pressure resulting from the reflex responses to stimulation of the semicircular canals. Disturbance of the semicircular canals results also in dizziness, but this is probably a secondary effect. Here is an organ which is of such basic importance for life that it is entirely automatic:[1] the receptors in the vestibule maintain equilibrium of the body by control of the tonus, or tension, of the muscles through the lower brain centers.

[1] But in this respect it differs only in degree from the other senses. The sense of strain in eye-movement functions in fine detail for most of the time that our eyes are open and even in sleep; yet many persons are not aware of the extent of these movements. Indeed all our senses gravitate in the direction of automatism, which is a mark of adaptation and organized service.

CHAPTER VIII

TRAITS OF PERCEPTION

We have now traced sensory experience from the physical fact, which we call the stimulus, and the resulting physiological event, which we call the nerve impulse, through its first emergence as a mental process in the form of immediate awareness of the sense qualities, which represent all the sensory aspects of the objective world; and have traced its systematic variations in intensity, duration, and extensity, so woven by associations into meanings as to give us knowledge of objects and their relations. In the present chapter we shall gather for further examination certain general traits of experience through the senses, particularly the nature of meaning, the rôle of action, the place of feeling, and the degrees of fidelity of perception.

Meaning in Perception

Sensation and meaning. — We have perceived an object, event, or situation when we have grasped its meaning with clearness and feeling in relation to action. Sensory experience lies between the two extremes: pure sensation and complete meaning — the one the raw material, and the other the finished product. As

we never in ordinary life experience pure sensation, so we probably never experience complete meaning: experience is always more or less fragmentary.

EXERCISE. — *Drop five ink blots on a sheet of paper and squash them by laying another paper on top. Write under each ink blot as quickly and spontaneously as possible three names of objects that you see in the blot. Observe that there is a tendency to see real meaning even in such utterly contentless things as ink blots, that the actual ink blot changes radically as you pass from one meaning to another, that your mind overlooks some and fills in other details to get meaning, and that the meanings are quite personal to you.*

Meaning personal. — As James has said, all perception is partial, personal, and purposive interpretation of definite and probable things. It is abridged for economy and efficiency by more or less automatic selection of the minimum serviceable and satisfying to the individual. What we shall perceive in a given object depends upon the background or setting we can furnish from our entire personal past. We perceive in a thing what our knowledge enables us to grasp: witness the botanist and the child viewing the flowering meadow. We perceive what our feelings, instincts, and impulses crave: witness the sight of a dollar. We perceive to a large extent what we will to perceive: witness that there is none so blind as he who will not see. We are generous in our perception and ready to build up our meanings from the slenderest material: witness the Gibson girl created from a few bold strokes of the pen. We perceive what we expect to perceive: witness the slowness in the discovery of common things. We are easily satisfied with partial and biased views: witness

the thousands of situations in which we are all old fogies. We realize the full meaning of situations to the extent that we live, or have lived, them over in our self-expression: witness the devotion of the lover. We perceive full meanings of things only to the extent that we grasp their relations in such a way as to result in a feelingful attitude toward them: witness the flag. Thus, each of us lives in his personal world though our senses are open to the same materials, and each one finds in the new object what is relevant to him at the time.[1] We perceive in accordance with the limits of our experience, knowledge, feeling, and will, and are always ready to compromise by being satisfied with such perceptions as serve our need; and in this there is beautiful design and wonderful economy.

Action in Perception

We have seen how perception is not a matter of passive impression, but a process of active construction in the development of meaning. Not only is perception an act of will, but it normally involves actual muscular movements. Let us examine the facts from the point of view of the motor aspects of the perception of space and time.

[1] "It is clear that the same object can have different meanings for different individuals, as the lines of action must vary in accordance with the habitual associations. The same stream which means to the boy a swimming place, to the sportsman a boating place, to the fisherman a fishing place, is to the manufacturer water power, to the chemist a combination of elements, to the landscape painter a silver surface, to the engineer a place to be bridged over. The technical term for a perception in which the relation to other objects predominates is by a tradition which has become slightly old-fashioned apperception." (Münsterberg)

Perception of space. — First, the mobile sense organs are equipped with inherited reactions called reflexes which facilitate and condition the perception of space, as in the eye adjustments, and even in the accessory muscles of the neck and chest. Pressure, temperature, pain, and the motor senses in the mobile parts of the body are likewise favored by motor adjustments, as in all forms of active sensing of pressure, temperature, and pain, and in all motor space through the kinesthetic senses.

Second, spatial impressions are intimately associated with responses which are the result of the sense impression itself and are so intimately tied up with it that they occur before the true space perception as a mental process has had time to take place; and the sensations of these movements figure largely in the sensory blend of this perception. A pin prick or the sting of a bee has already been responded to by the time the pain is felt. Something threatens the eye and *it* closes before *I* know. These movements are called reflexes. They blend gradually into voluntary action and play an important rôle in our normal space adjustments through the senses because they facilitate the performance of the act, which is involved in the perception, without calling for active mental effort. This unconscious and immediate transference of sensory impressions without delay or waiting for conscious response is a principle without which skill and grace in movement would be impossible. In so far as the impressions result in meaningful perceptions, they involve the original sense impression with secondary impressions of associated responses.

Third, we find the concept of spatial relations in all the senses developed in terms of movement. The infant seeing the dangling red ball does not at first see its distance or size. These impressions get perceptual meaning when associated with reaching, clutching, and grasping movements. Meaning as distance, size, contour, or volume develops in terms of action. Even to the adult, such ideas as " I have felt it," " I have felt around it," " I have measured it in some way of action," are present in the background of visual perception.

Fourth, impressions through the eye and other spatial senses must be vitalized by experiencing space in its functional relations as was shown above under meaning. The man can see what a boy is doing because he has been a boy; the old maid often cannot. What is going on before your senses has vital meaning to you just to the extent that you have lived the situation or something effectively analogous. The perception of things in space, then, is not a passive " photographic " process, but involves a dramatic performance in the reflex adjustments to facilitate the impression. The power of space perception develops to the extent that it is used. Perception develops essentially in play.

Perception of time. — We have found duration an immediately given attribute of sensation, like intensity and extensity. To exist at all, a mental process must exist in time. But, in the perception of intervals of time, we estimate duration in terms of achievement — of what we did, do, or think of doing. As in primitive barter with goods, we have developed a system of valuing one thing in terms of another, using for basic refer-

ence the periodic movements in our body, such as the beat of the heart, breathing, or the pendular swing of the legs in walking. Habitual imagery, such as the visual-motor image of the pendulum of a clock, or the motor image of the heart beat, dominates in our time perception. In music, we hear rhythm just to the extent that we perform it in overt, inceptive, or imaged movements. Verify this in listening to a simple rhythm in music or poetry. If there is an error in time, you will observe it by the fact that the played time values fail to coincide with your self-acted time. Thus, the motor theory of time and rhythm is analogous to our visual interpretation of space in terms of tactual and kinesthetic experiences with objects.

Just now I heard the clock strike nine. That is a time milepost. But so is breakfast, dressing, going to work; so are hunger and fatigue, in a vague way; so is the work of writing ten pages at a normal rate; so is the performance of routine duties; so are the periodicities of light and darkness, rest and fatigue, and the regular processes of occupation. Some of us "rise with the birds" and "go to bed when the chickens roost." If we wake up at night and wish to know what time it is, we have recourse to the signs of the light of dusk and of dawn, hunger, rest, milkman, traffic, the song of birds.

Feeling in Perception: Affective Tone

Two qualities. — All sensory experience is either agreeable or disagreeable. This feeling aspect of perception we speak of as its affective tone. The dividing

line between the agreeable and the disagreeable is theoretically a mathematical point; but practically there is a neutral zone in which the affective tone is below the threshold of awareness.[1]

Speaking figuratively, things either attract or repel, or both; and the affective tone is our vague awareness of our automatic leaning toward or away from the object. The purpose of this "leaning" in perception is to facilitate the response by this unconscious adaptation for action. It is really an extension of the reflex, immediate, and purely unconscious response to sense impressions, which is a condition for the preservation of life. The reflexes take care of the simple, immediate responses in that taste, odor, pressure, and other sensations lead directly to movements of aggression or antagonism. The affective tone, as a conscious accompaniment of perception, aids in the complex responses to the perception. The senses furnish the principal material for esthetic appreciation, both in nature and in art. As is proverbially known, pleasure is not attained by direct pursuit, so there is no immediate sensation of pleasure in sense experience as a message in itself. We do not experience pleasure in itself but in the pleasurable aspect of things, events, situations. We do not go out into the woods in the springtime to see beauty in itself, but to find pleasure in beautiful things. The affective tone of perception is a sort of concentrated and elemental evaluation of the thing in the very act of per-

[1] Some psychologists regard this affective tone as a two-phased attribute of sensation. Our only reason for not recognizing this is that affective tone is not peculiar to sensation, but is present in all mental processes. The facts of perception are, however, aptly described from either point of view.

ception. It lends richness, warmth and coldness, and vitality to sensory experience; it is our higher life projected into the sensory experience.

Complexity of the affective aspect. — Let us take a simple example of feeling or affective tone, the pleasure of a whiff of odor from a rose. Even in such a simple process, limited in time to a few seconds, the situation is very complex. There is, first of all, an impression (sensation) of odor. The sensation of odor probably carries with it associations of color, form, softness, and other sense qualities. Images of these may even dominate in the perception of odor. In the act of perception, you are in the presence of a rose with all its meanings. Each of these associated meanings, even if only subconscious, follows the principle of stimulus-response and tends to run into action. Perhaps the dominant images are not even images of a rose but of an associated object, as garden, mother, sweetheart. Perhaps the dominant image, for a moment, is not even agreeable, but an image of death, rejection, financial distress. Whatever these associates may be, each tends to elicit response in the organism. From all these associated responses comes a mass of sense impressions of the action and the attitude of the organism. The same stimuli act also upon the organs of secretion and circulation, and these in turn upon the brain in such a way as to raise or lower the level of mental activity. The pleasure of the odor is, therefore, the awareness of a rose as set in a diffused consciousness of attitude of the organism in response, intensified or dulled as the case may require. The agreeable or disagreeable is the rich and meaning-

ful knowledge of the rose as toned by the reactions of the organism.[1]

Hallucinations and Illusions

Nature. — There are two stages in perception: the sensory cue and its interpretation or setting in all past experience. A perception in which the sensory cue is misinterpreted we call an illusion; a perception in which there is no sensory cue we call an hallucination. This is the conventional distinction between illusion and hallucination. Hallucinations and illusions are real perceptions in that they are experienced in sensory terms, and we believe in them exactly as in the case of a true perception. I can imagine a ghost, but such a mental picture of a ghost does not become an hallucination, because I do not then actually believe that I *see* it, or am aware of it through some other sense.

The rôle of the sensory cue in normal perception is greatly overestimated. For instance, you get a momentary glimpse of some part of a man on the street and instantly you say to yourself, "That is John Smith." Now perhaps the mark you sensed was a trifling one — hat, swagger, mustache. Some trifling part may set off the perception of the whole. This done, you feel, as in this case, that you have seen two eyes, two ears, nose, neck, fingers, possibly toes, and countless peculiarities in structure, behavior, and the character of the man. In such

[1] "The green trees, when I saw them first through one of the gates, transported and ravished me; their sweetness and unusual beauty made my heart to leap and almost mad with ecstasy, — they were such strange and wonderful things. The skies were mine, and so were the sun and moon and stars, — and all the world was mine, — and I the only spectator and enjoyer of it." (Thomas Traherne)

a case the sensation is really insignificant; the perception is an elaborate tying-up with itself of previous percepts in the original picture of the man as you know him to be. "I see John Smith" represents a complex affair initiated by a strategic group of sensations, selected by interest and set in the organized concept of the man as you might well think of him without seeing him at all.

Now, suppose that upon the second glance you exclaim to yourself, "Why, that is not John Smith; that is Sam Jones!" In that case your first experience was an illusion. It was a real perception; it was convincing; it was believed in; it was clear; and yet, as events proved, it was a misinterpretation.

Let us further suppose that it has grown dark and you are sitting on the veranda waiting for your very dear friend, John Smith. There is a rustle, a sound of footsteps, or a passing shadow, and you rise with a joyous exclamation, "There he is!" only to find that you had been deceived; this, again, was an illusion.

There probably are no genuine hallucinations; *i.e.*, perceptions without any sensory cue. All supposed hallucinations must be reduced to illusions — false perceptions, in which there is some sensory cue, however inadequate it may be.[1]

Thus, we shall find that the bear in the bush is made

[1] This is well illustrated in a hypnotic experiment. The subject is hypnotized and told that he sees a picture of the king on the back of a card in a package of white calling cards. He asserts that he sees it. The cards are then shuffled and he is asked to pick out the card with the picture, which he does correctly. The cards are shuffled again, and this time the cards are turned around without his knowledge. When asked to find the picture again, he succeeds as before; but, immediately upon seeing it, he turns the card around because, as he says, the picture is upside down. Now in this case the subject probably fixes upon some trifling flaw in the paper as a starting point, *a point de répère*, which became his sensory cue, however inadequate.

of the bush; and ghosts are made of shadows, and the like. The hallucinations of the insane are based upon some sensory irritation, and even our dreams are made of "dream stuff," as we shall see later. It is, however, convenient to retain the term hallucination for those illusions for which we are unable to trace any stimulus.

Normal and abnormal. — A normal illusion or hallucination is one which occurs as a natural by-product, bias, or momentum, in normal mental life, and may be predicted under normal conditions. When abnormal illusions are present, the abnormality may be due to disease, physical or mental, or to any extraordinary combination of circumstances which may distort perception. Normal simply means common, average, or standard.

We have seen in the preceding chapters that the senses furnish a rich display of normal illusions. The same is true for hallucinations, though not so easy to demonstrate. In normal waking life we probably see, hear, touch, taste, smell, and otherwise "sense things" which, if examined, are not these things at all. We persistently see colors which are subjective, such as in contrast, after-images, and transition colors. We hear rhythms which are purely subjective. We scent odors which are but the "figment of the imagination." We constantly have a taste in the mouth. These experiences are all more or less normal. The dream furnishes us the most perfect specimen of a normal hallucination. The dream object is present, is actual, real, active, and convincing. It is a real presentation, but false. There are four large classes of hallucinations that are recog-

nized as abnormal. They are the hallucinations of the insane, the functionally sick, the hypnotized, and the highly suggestible. The reality of the suffering in functional diseases is sadly notorious, yet, from the point of view of psychology, natural and orderly. The illusions and hallucinations of the insane are characteristically systematic, as in fixed ideas of persecution and the elational experiences of grandeur.[1]

The study of hallucinations of persons under severe mental strain, vivid anticipation, superstition, and ignorance is one of the weirdest chapters of history.

Synæsthesia

The term synæsthesia means "felt together." With many of the sensory modes an entirely foreign sense quality may appear in the perception. In "colored hearing," colors are associated with tones so that the moment the tone is heard it is also seen and projected in space as a color. Each instrument may have a color accompanying its timbre; *e.g.*, cello, indigo blue; clarinet, yellow; trumpet, bright red; flute, dark red. The entire pitch range may be represented in the colors of the spectrum, high tones usually having bright colors and low tones dull. All the variations in the intensity, timbre, and volume of tones may be *seen* in corresponding nuances of color. Words, names, persons, the alphabet, etc., may appropriate color.

One of the commonest forms of synæsthesia is "number forms"; names, letters of the alphabet, days, months,

[1] On this point students should read a most illuminating book by Mr. C. W. Beers, "A Mind That Found Itself," which is an account of the organization of perception that may prevail, even in the most acute forms of insanity.

etc., when thought of, are visualized in a fixed scheme out in space.[1] To those who have them, to see these forms seems as natural as to think of a number. To those who do not have them, they seem surpassingly strange.

Another aspect of these concomitant sensations is a fixed association of feelings of agreeableness and disagreeableness for special tones, colors, odors, words, etc. Odors are particularly rich in these feeling associations. A further examination of the same principle is the personification of inanimate objects. There is, after all, but a step from the simultaneous presence of two or more sense modes as in the taste, smell, and pressure of an apple to this synæsthetic perception of analogous sense qualities and other objectification in space. Most of us have visual impressions of all objects that come to our mind. Number forms are merely habits of visualization represented in definite schemes. These schemes sometimes have a traceable origin, as in the division of the alphabet into two columns, the way they used to appear in the old primers. We are, therefore, disposed to question the physical explanation that has been offered in terms of proximity of brain centers and to say that synæsthesia is a natural habit, though somewhat fanciful and weird.[2]

[1] See illustration in Baldwin's "Dictionary of Philosophy and Psychology," II, 464–5.

[2] These phenomena are rather common. One investigator, examining 203 college freshmen women, found 32 cases of colored hearing, 61 cases of number forms, and 17 cases having both. Estimates of frequency of synæsthesia run from 5 to 40 per cent of normal persons. The numbers are unreliable because it is a question of degree. The synæsthesia is more profuse and changeable in childhood; forms carried over into mature life become correspondingly fixed. Even after years have elapsed, the same space form and the same color scheme may persist.

TELEPATHY

Telepathy or thought transference is the theory that communication between mind and mind may take place otherwise than through the known channels of sense. A vast amount of experimental work has been done in this field, particularly under the auspices of the Society for Psychical Research. Among these are the following types: (1) a hypnotic experiment in which the subject is directed to receive communications otherwise than through the known channels of sense, as when the hypnotist tastes a substance and the subject is expected to experience the same taste, or as when the attempt is made to hypnotize a person at a distance without prearrangement; (2) waking persons attempting to transfer sensations from one person to another on the same theory; *e.g.*, one observer will sit in one room and another in an adjoining room attempting to write down or sketch what is seen in the other room; (3) as in the feeling of being stared at when one person attempts to have another, seated some distance in front, turn around at a telepathic command; (4) answering questions mentally asked by a distant person; (5) apparitions; as where one party agrees with another that, at some time known only to himself, he shall appear; *i.e.*, be seen in a hallucination on the conditions set by himself.

The evidence from spontaneous cases is, of course, much more prolific. Premonitions, haunted houses, "hunches," visions, inspirations, exaltations, supernatural guidance, the dæmon of Socrates, phantom voices of the dead, phantom sounds, countless super-

natural manifestations of mysterious modes of communication, run in a channel from most primitive mythology to the most refined spiritistic cults of to-day. Between experiment and crass spontaneity lie many practices in mind reading for public entertainment, for pay, and more frequently for private devotion, and spiritual edification. Here belong the claims of "second sight" in the answering of sealed letters, the answering of mental questions, all the forms of muscle reading, the automatism in automatic writing, table tipping, planchette, and ouija board.

A critical and detailed examination of the vast array of testimony for the alleged existence of the power of mind to transcend the laws of the senses is out of the question here. Investigations in this field have been profitable for scientific psychology in that they have revealed to us general laws and hidden resources of the human mind operating in this borderland field. They have given us valuable hints concerning the sources of error in psychological experiments, and have revealed to us the wonder of automatism and many of the marvels of the mechanism of personality. But have they proved telepathy?

No one is better prepared by technical knowledge and insight to recognize such proof than the psychologist; no one could be more eager than the psychologist (unless it be the religious devotee) to welcome it. Wireless telegraphy, rightly so highly regarded in physics, would be a crass trifle to the evidence of telepathy if it were true, but the general verdict of psychology is that telepathy has not been proved.

Telepathy would offer an easy mode of explaining some of the most baffling situations in life, but, on present evidence, the psychologist is not justified in accepting telepathy as a principle of explanation. Yet he must either explain it or explain it away; *i.e.*, whether true or false, the alleged phenomena of telepathy should be considered in an extended study of psychology.

CHAPTER IX

ATTENTION

Nature of attention. — To attend is to focus consciousness, to gain clearness of images or ideas, to make motor adjustments for clear impressions, to be prepared, to take an attitude of muscular tension, to anticipate the coming in pre-perception, to explore, to exercise curiosity, to react consciously to stimuli, to feel effort, to be interested, to will. Such phrases, although more or less fragmentary, are mutually supplementary indications of what we ordinarily mean by the experience of attention.

Attention is not a mental process in itself: it is rather a name for the form in which mental processes tend to present themselves and may be best described as the focusing of consciousness. The physiological explanation of this focus is to be found in the neural laws of stimulation, facilitation, and inhibition.[1]

Our problem, then, in this chapter, is to gain some insight into how it comes about that, of the multitude of external impressions which are thrust in upon us, and of the vastly more intricate centrally aroused associations, only a few, and these often the desired ones, come into the clear focus of consciousness, while the vast mass is

[1] The principle of stimulation has been abundantly illustrated in the study of sensory experience; facilitation or selection will be explained in the treatment of the laws of association; and inhibition under such heads as instinct, impulse, and neural theory.

relegated into more or less remote recesses of marginal consciousness, the subconscious, or the purely physiological levels.

We have used the term attention familiarly in the account of sensory experience. We shall find that memory and the learning process in general are interpreted in large part in terms of the mechanism of attention; that to imagine is to train the focus of consciousness in search for something new, somewhat as the beams of the search-light go out over the sea and here and there spot a distant vessel; that reasoning is persistent and planful focusing of consciousness upon successive features of similarity and difference in the relations among percepts and concepts; that will and action are accounted for largely in terms of attention; and that even feeling and emotion, which seem to be forced upon us organically, are modified and often enhanced or effaced by the course of attention. Yet, let us not forget that attention does not do these things; it merely denotes that form of consciousness in which the sensation, the percept, the image, or the idea, stands in the focus of consciousness.

Laws of Attention

In order to throw into relief a series of principles which operate in determining attentive consciousness, we may formulate a series of laws of attention, all of a somewhat practical nature, bearing in mind that the term "law" is here used in a rather free sense, as indicating general tendencies or conditions. For the sake of brevity, the important distinction between the attracting of attention

and the holding of attention is not elaborated in these laws, but must be constantly borne in mind. A few simple experiments will introduce the subject.

EXERCISE. — (*a*) *Hold your watch away from your ear at a point where you can "just barely hear the tick" and observe that the sound periodically appears and disappears, and this fluctuation is continued as long as you listen. Record approximately the average time of "sound heard," and the average time of "sound not heard," in ten trials.*

(*b*) *Change in attention. — Regard steadily the roundness of the period at the end of this sentence for one minute, and recall (after the minute) how your attention changed from object to object while you were doing your best to concentrate for one minute upon that point alone. Repeat, verify, and write full list of changes observed.*

(*c*) *Movement. — Again, regard the roundness of the same period very intently for one minute, and observe what bodily movements take place in this act of attention. Repeat, verify, and record full list of movements.*

(*d*) *The division of energy. — Count consecutively, as fast as you can, from 1 to 100, and at the same time write consecutively, the numbers from 1 upward. Record* (*1*) *time required,* (*2*) *how many numbers were written,* (*3*) *reason for mistakes or halting,* (*4*) *if at any precise moment you attended clearly to both processes at the same time.*

1. Tension. — The attitude of attention is that of tension. Photography furnishes us a good illustration by analogy. The photographer wants a clear image on his plate; you want a clear image or idea in consciousness. Neither should be obtained by mere chance. There should be deliberate selection of object, approach, adjustment of instruments, readiness for recording, provision for developing, and well-timed action, all of which imply a condition of bodily preparedness or suspense — muscular tension.

This was well illustrated in Ex. *c*. You made all the necessary muscular adjustments for the focusing of a clear image upon the retina. You braced up bodily and threw your voluntary muscles into a state of suspense. The whole organism became tense. Some of these adjustments served immediate purposes, such as facilitating perception or response, eliminating distraction, or controlling circulation and aëration of the blood. Many were, however, reflexes which are only survivals of formerly useful action. The excitation of the internal organs of secretion was, although not observed directly, an important phase of this tension. Most of this bodily action was favorable to attention, and much was a necessary condition. Therefore, if you wish to attend, *strike an attitude of bodily tension*; *brace up, and be in a position of readiness.*

2. **Novelty**. — Novelty is the most characteristic object of attention. Attention is a scout which tends to take notice of anything that is out of the ordinary — that may be significant. In modern advertising, and in teaching, *e.g.*, we find a remarkable array of devices for introducing novelty to catch attention and to hold it. This law is conditioned upon the fact that we tend to grasp familiar units, objects, or events subconsciously; *i.e.*, without attention; and it is well that we do so, — the less attention to these, the better. The real purpose of attention is to deal with new situations. It is in the interest of efficiency that we should not pay attention to 99 per cent of the images and ideas which function efficiently in our stream of consciousness, and that attention should be reserved for the fraction of 1 per cent

(to use figures very roughly), which call for new adjustment. The law may, therefore, be stated from two points of view: (1) that in the normal flow of perceptions, images, and ideas, we attend only to the novel, or that which calls for adjustment; and (2) that to attract attention, situations should contain elements of newness. The former of these rules is really a condition of the latter, for it is by trusting the automatic operation of routine processes that we reserve and hold available the pulse of attention required to meet new adjustments. Therefore, to cultivate the ability to meet new situations attentively, *cultivate progressively the ability to make routine automatic and thereby throw new situations into effective relief.*

3. Intensity. — Attention rests primarily upon the law of intensity in association to be discussed in Chapter XI. Large, heavy, strong, severe, striking impressions and associations attract attention. In walking, we notice houses and trees more than individual pebbles and leaves; in eating, we notice the principal seasoning more readily than any one of the delicate elements of flavor; in thinking of virtue, we fasten more readily upon cardinal virtues than upon a minor virtue. However, a loud sound, a strong light, a penetrating odor, do not in themselves hold attention, except for a short time. Softness, mellowness, delicacy, gentleness, often attract attention. Subtleness and hair-splitting in thought hold attention. We attend to anything because it is extremely large or extremely small, extremely strong or extremely weak, extremely complex or extremely simple. It is the law of extremes, the extraordinary. The law of intensity must, therefore, always be interpreted with

reference to the law of novelty and closely related laws. Nevertheless, other things being equal, this is the practical rule: to attract attention, *employ a strong impression or association.*

4. **Action.** — The object of effective attention leads to immediate expression. The term "action" is here used in both the physical and the mental sense to denote executing, or putting into effect. Thus, your eye catches an object and you turn to grasp it; your imagination focuses upon an idea and you pursue this idea mentally; you have a sensation of contact in the neck, and you take cognizance of it. In all these cases, the follow-up action leads to trains of foci of attention, radiating consecutively from the original object of attention. It is like walking; you may merely think of walking and get nowhere; but if you take the first step, you are in the position which precipitates you into the next. So in reading, searching, examining, discriminating, thinking — in any act which requires a movement of focal attention — you get the continuity by carrying into action each focal image in turn. This is a rule against dawdling and day-dreaming; it is the rule of alertness in continuity. As you cannot walk by taking an occasional one of the necessary steps, so in attention, each step must be executed in turn if you are to make progress. As you walk best if you follow a natural gait without interruption, so your attention becomes effective if each unit or idea in the mind is clinched in natural sequence. Therefore, to secure effective attention, *express the object in mind in continuity of appropriate and consecutive action.*

5. **Change.** — There can be no continuous attention

to an unchanging object. Attention is action, exploration, hunting, pursuing. You found in Ex. *b* that there could be no effective standstill in the act of attention for any considerable period of time. Even in attention to the roundness of the period for a moment, the point of view changed: a series of features was noticed; the point of regard moved; you noticed in turn different relations of the period to adjacent objects; attention vacillated between percepts and ideas; there were marked periods of inattention; you did not attend to "the roundness of the period" for one minute. The remedy is not to attempt to do the impossible; but rather to take advantage of this inexorable law of change by training yourself to move the point of attention consecutively for a purpose at a favorable rate; *i.e.*, to discriminate in turn a number of fine points of detail, the sum of which will constitute a relatively complete grasp of the object. In case of the period, change of attention about the roundness of the period would reveal, *e.g.*, that it is not round, that the period seemed to move and change in size, brightness, and shape during observation, and that you saw a round fringe — all of which were relevant facts, and served to keep attention from wandering from its real object for want of direction. Poor attention chances upon a clear image now and then; but good attention takes advantage of the law of change and penetrates. *Therefore, form the habit of regarding relevant features of detail within the specific object in rapid succession.*

6. **Periodicity.** — Attention flows in waves. This was illustrated in Ex. *a*, where you found that, even with

the most extreme effort to hear the sound continuously, it appeared and disappeared with periodic regularity, depending to some extent upon the steadiness of the effort, the relative loudness of the sound, the absence of distraction, your keenness in marking the appearance and disappearance, and many other factors. Analogous periodicity, though not so easily observed, probably occurs in each of the other senses, and even in the higher mental processes. In this natural periodicity lies the foundation for rhythm in poetry and music, and even in plastic and graphic arts. But all forms of skilful, natural, and effective mental work in daily routine are organized upon the same principle; *i.e.*, the conscious task naturally divides itself into units adapted to the natural pulsations of attention which average less than 10 seconds for the complete wave.

But this is a periodicity within a periodicity. Observers were required to listen to sounds of varying intensity and make the appropriate response every second during the two hours. The detailed records of achievement by several observers show that there is a large periodicity in which the two-hour period tends to fall into three or four waves which we call hour or half-hour waves. Within these, we readily observe ripples, which have the same sort of regularity and may be designated minute waves; and within the minute waves occur the second waves of which we have just spoken. These second, minute, and hour waves, under the most exact conditions of experiment, come out irresistibly and give, in careful and stable observers, the same general characteristics. To these may be added the daily

period, for it is well known that our attention is at its best at a certain time in the day and at its poorest at another time, and there may be two or more waves in the diurnal period. Fig. 14 is a photograph of a vibrating flame, the contour of which beautifully illustrates and symbolizes this principle of periodicity within periodicity.

The applied psychology of attention, therefore, urges that we so group our units of effort as to fit them into

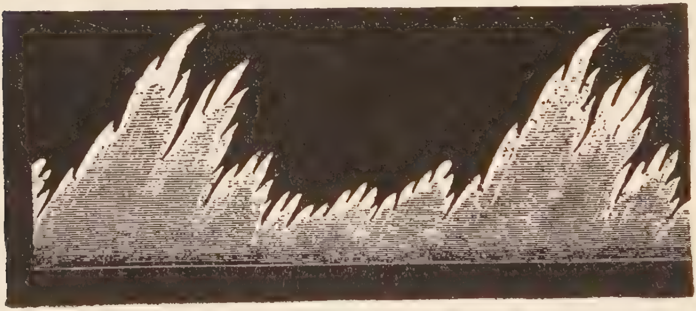


FIG. 14. — The periodicity of attention

natural second, minute, hour, and day periodicities, in which the achievement at the crest of the wave is made possible by the relaxation in the preceding vale. Nature exacts the fluctuation at seeming loss of efficiency; but by skilful forethought we can take advantage of the periodicity and vastly enhance achievement by working in well-timed spurts in conformity to natural fluctuations. The commonest application of this principle is in rhythm. Therefore, *fit the task to the normal attention wave.*

7. Timing. — The attention wave is most effective at the crest. We may represent this roughly in Fig. 15 by assuming that, for a given time, *e.g.*, five seconds, a certain

amount of energy is available and that this may take the form of *a*, *b*, or *c*; where *a* denotes relative inattention or suspense under uncertainty, as where the time of occurrence is not known; *b* denotes a spread of pulsation on account of a vague expectation that the object will appear during this period; *c* denotes a concentrated form of discharge which occurs when it is known that the impression will occur at 3. The three vertical lines, 1, 2, 3, then denote relative efficiency of the grasp of attention under these circumstances. If the object came at *y* or *z*, in form *c*, the relative effectiveness would be indicated by these vertical lines respectively, as compared with 3.

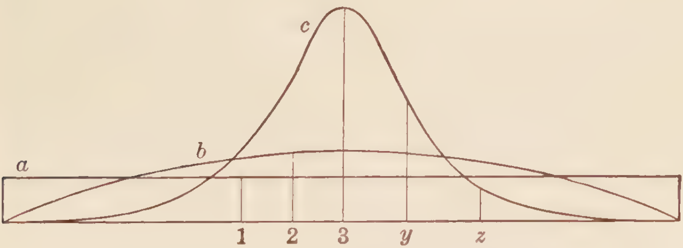


FIG. 15. — Types of distribution of attention

In laboratory experiments, where the observations must be made under the best conditions of attention, we therefore employ warnings or signals, which mark off the coming of the stimulus one or two seconds in advance of its appearance, and thus enable the observer to catch the object in the peak of attention. This is a principle which is carried into effect in all our skilful use of attention by the operation of habits of making the necessary attack at the favorable time. In most mental effort,

either the object is free so that it can be caught on a momentary peak of attention, or, if recurrent, there is a periodicity or rhythm in which each period becomes the signal for the next following. Therefore, to secure the keenest attention, *catch the object at the peak of a sharp attention wave.*

8. Rest. — An attention crest can be obtained only at the expense of an attention vale. Well-chosen periods of rest favor attention. This principle is embodied in the timing, periodicity, and rhythm involved in the preceding laws, where nature automatically provides for recurring moments of relaxation in which there are natural periods of attention for day, hour, minute, and second (and neurologically hundredths of a second) groups. But aside from the periodicity of rest, we can give even momentary attention only to the extent that it is preceded and followed, almost immediately, by a more or less complete relaxation, as was illustrated in Fig. 15. The best workers, in occupations which require what appears to be continuous attention, are those who can subjectively group the work into periods, or rhythms, so that there are recurring units of complete relaxation. The best worker is the best rester. In adding, for example, the expert runs down his column in clean-cut units, and, even when going at a very rapid rate, has proportionately longer periods of relaxation between each unit grasped than has the beginning plodder, who scatters his energies. The shorter units of rest are bridged over by the feeling of continuity, which we have found is an illusion. In studying this lesson, you get the best result if you have come to it from a short period of complete relaxation, and have

thrown yourself with unfailing persistence into an effort to master the new situation, and then relax completely when a given task is done. A poor student often works all the time; the good student revels in abundant relaxation. Relaxation, diversion, change, play, sleep, are primary conditions of effective attention. But never mix relaxation and work! Let there be a clean-cut periodicity — incisive distinction between your exertion and your relaxation. The period of rest may be comparatively short. A ten or fifteen minute nap after the midday meal may add the equivalent of hours of effectiveness to the afternoon work. Three minutes of complete relaxation when you feel dullness coming on may add an hour of effectiveness to your study. Therefore, to keep attention at its best, *provide adequate and timely relaxation.*

9. Grouping. — Attention is effective in proportion to the capacity for grouping in large units. If an instantaneous exposure is made of a group of letters, you can grasp in a single span of attention, without eye movement, from three to six letters. But if the letters are arranged in words of four or five letters each, you can grasp almost as many words as isolated letters. That is to say, attention is favored by the grouping of coherent units. It is a significant fact that the scope of attention does not depend so much on the size or complexity of the object, as upon its meaning. A long, familiar word, such as *university* or *psychology*, is grasped as easily as a short word, such as *rear* or *tow*. In the psychology of reading, we find the most interesting application of numerous principles which determine the span

of attention. A child attends to the letter, or part of the letter and, through the art of reading, gradually learns to extend his span of momentary attention in such a way as to use larger and larger units, running through the letter, syllable, word, sentence, and paragraph. The same principle applies to abstract thought. We develop capacity or skill chiefly through the acquisition of capacity for holding larger and larger organized units in the attention span. Therefore, to improve attention, *organize progressively larger and larger units of grouping for the attention span.*

10. Division of energy. — We can attend to only one thing at a time. In Ex. *d*, even though both processes moved smoothly together, you did not give focal attention simultaneously to the two processes at any moment. Failure to notice this is merely inadequate introspection. What happened was that the attention oscillated in flashes from one to the other, and the two processes could go on simultaneously to the extent that one or both, at a given moment, was either automatic or could be carried on in the marginal consciousness. Speaking and writing numbers are both well-learned processes, so that the stable observer may save time by doing the two together, particularly after a little practice, because attention is required only for certain critical moments in each act, and these critical moments can be met in turn, — not simultaneously. The study of the character of conflicts and mistakes throws much light on the rôle of attention at such critical moments.

The fact that we can give focal attention only to one feature at a time should, however, not discourage us

from doing two or more things at the same time: indeed, we should cultivate the ability to be undisturbed by parallel activities, and to be able to concentrate upon only the critical moments of each in turn. The stage performer who keeps from two to ten balls in the air without being flurried is a model in this type of skill. He tosses the balls high enough to allow him ample time for each one, and the task seems easy and graceful because he pays no attention to any ball except at the critical moment. Even the most complicated feats of conversation, observation, memory, and reasoning may be carried on simultaneously in this way through specialized training of a gifted person. In our ordinary duties of the day, we frequently do more than one thing at a time. If we did not, we should be quite helpless. This must not, however, be mistaken for encouragement to scatter our energies; on the contrary, it is a charge to concentrate at the critical moments. The significance of this principle is not so much in the ability to do several things simultaneously, as in the use of attention economically in one thing at a time. We chose the illustration of the attempt to divide attention to demonstrate that this cannot be done except by oscillation from one process to the other, and in this way, to illustrate the significance of critical moments. Therefore, to cultivate effective attention, *train yourself to conserve attention for critical moments only.*

11. Purpose. — The readiness with which a feature shall become focal in consciousness varies with the definiteness of the point of view in anticipation (purpose), and the facility for referring the new experience to a known

class. This is the law of apperception, which was illustrated in the sections on *Meaning* in Chapter VIII, and on *Illusions* in Chapter IV and Chapter VII. Its application to the higher mental processes can readily be made.

What shall become focal in your stream of consciousness when you encounter a new object, situation, relation, or event depends upon your point of view or purpose at the moment and your capacity for pigeonholing it promptly in some known class of past experience. Even the simplest object or event may have dozens of meanings. What it shall mean to you in terms of attentive consciousness depends upon the purpose you have in mind. The blurring of meanings is as confusing as the blurring of objects in the securing of a clear image. It is as important to have a single purpose at a time as it is to have a single object at a time in focal attention. Attention that conforms to this rule is called expectant attention. Therefore, to secure expectant attention, *anticipate the coming new feature from a selective point of view and refer it to its appropriate class.*

12. Interest. — The feeling of interest results in an attitude favorable to attention. Attention has often been described in terms of interest, but it has been well said that things are interesting because we attend to them : we do not attend to them because they are interesting. Nevertheless, interest is a pleasurable feeling which forms a part of the cycle of the process which constitutes sustained effort. It may be regarded as the affective phase of the state of attention, or as a mood which accompanies it. We, therefore, speak appropriately of interest

as a condition of attention in education, play, art, sport, and work, and thereby mean that the mind is entirely engrossed upon the object of attention so that the feeling of pleasure sustains a favorable attitude for continued passive attention, with a minimum effort. This interest cannot be gained by direct effort; like happiness, it must be sought indirectly through a wise choice of occupations. Therefore, to hold attention, *so order your life as to cultivate an attitude of interest in what you do.*

13. Effort. — Attention is an aspect of will. Indeed, attention has often been described in terms of mental effort, or will emanating from a self, person, or being, somewhat beyond and independent of the psycho-physical organism. Without entering upon the very complicated issues involved in that matter, we may point out that the feeling of effort which we have in paying attention is made up essentially of kinæsthetic sensations of strain, coming as a result of the mass of physical activities involved. However, the effort, will, decision, or intention involved in the act of voluntary attention may be regarded as a general attitude of the mind resulting from consciousness of purpose, consciousness of the means of attainment, and consciousness of the outcome, so concentrated in one moment of focal consciousness as to favor the various motives of attention. This is what is implied in the command "Attention!", the exhortation "Pay attention," or the will to attend. Effort thus understood denotes a vital step in the causation of attention and is often taken to designate the total experience in attention as self-expression. Therefore, to secure the most effective voluntary attention, *do not*

merely permit, hope, or desire attention, but make an incisive effort to attend.

14. Form. — Attention may be divided into voluntary, involuntary, and secondary passive. The best form is secondary passive. Voluntary attention is that form which requires marked effort and deliberation; involuntary that which occurs spontaneously as the result of some feature in the situation; secondary passive attention has in common with voluntary attention a purpose, and in common with involuntary attention facility and economy of effort. It develops when the act has become more or less passive, as a result of the selection, survival, and development of vital purposes or interests which more or less automatically lead to precise anticipation and sustained gratification in habitual action. In other words, secondary passive attention occurs in connection with derived or cultivated interests as distinguished from sporadic interests. What in the first instance may be voluntary attention should, for permanent use, be made progressively passive. That is to say, if you want to strengthen attention on a large scale, do not depend upon sheer effort in the individual act, but cultivate the habit of appreciation of and desire for the class of things to which you want to attend. Therefore, *cultivate the secondary passive form of attention.*

15. Skill. — Attention functions through organized groups of skill. Although concentrated attention represents a moment of intense consciousness, it can be obtained and sustained in effective precision or periodicity only by the operation of a hierarchy of habits, each more or less automatically coöperating to bring about this con-

dition. The above laws each designate such habits. The habit of clean-cut attack, the habit of relaxation, the habit of anticipating in pre-perception, the habit of hitting hard, the habit of ignoring distraction, the habit of carrying image into action, the habit of bodily attitudes, the habit of observing in terms of meaningful units, these and many others, in a well-ordered life, should function quickly, easily, and harmoniously to bring about the moment of even the most rigidly voluntary attention. Effective attention is not a thing to be brought about by original and independent mental effort, but represents a skill based upon the gradually acquired system of habits. Therefore, to acquire the power of attention, *cultivate* (*i.e.* train yourself in) *the fundamental habits of precision and alertness, which are necessary conditions for ready and effective effort.*

Bodily Action in Attention

Focusing movements. — Physical movements accompanying attention are so conspicuous that many authors have thought that attention consisted essentially in such bodily movements. It is to be noted, however, that they do not precede attention, but usually follow, or accompany the act of attention. These movements may be classified into three or four groups. We have, first, the adjustment of the sense organs necessary for clear perception. This is best illustrated in the act of vision. For example, if we are to make a fine distinction in the examination of an object, the whole body, or at least the head, turns in the direction of the object; the eyes engage in scouting movements to locate it and turn so as to

throw the image upon the point of clear vision, converge for distance, focus for a clear image, and adjust for appropriate illumination. These movements are, therefore, a condition of clearness in the image, which is the characteristic of attentive vision. Similar, though not so mobile, adjustments are made in each of the other senses.

Accessory movements. — There is another class of movements which are accessory to these, and result in a general adjustment of the body, tending to throw all the voluntary muscles into a state of tension, the body being in a state of suspension, like a trigger ready to go off. There is a general tendency of reaching for the object, or in some other way apprehending it. In viewing a beautiful sunset, there is a tendency to step forward, instead of back, away from it. In listening intently to a person speaking, we approach or lean forward, but as soon as the attention lapses, the muscles relax, and we fall back. It is just as essential in attention that the muscles of response shall be cocked, as it is that the muscles of sensory reception shall be focused.[1]

Movements by analogy. — In all attention, we find an exceedingly interesting recapitulation of movements which in the past have been useful in analogous situations. By a very interesting biological principle, many such adjustments are made inceptively, or more or less overtly, in acts of attention where perception, through a sense organ, is not involved. When we try to recall the shape of an object, there is a tendency to

[1] An illustration occurs at the moment of my dictating this paragraph : I caught myself having pinched a note, which I held in the hand so tightly that I suddenly became conscious of a painful strain in the hand, the result of the general attitude of muscular tension in attention.

make all the movements of visual adjustment for actual seeing, or in thinking of a sound, to make the adjustments for listening. Although they serve no direct function, they facilitate attention to the image or idea. In a similar manner, the attitude of readiness for response is taken in attending to objects which do not call for motor response. This is a phase of the language tendency in the use of gesture, and facilitates attention because it gives form for the expression in muscular tension. In like manner, there is a tendency to point toward the organ of attention, the forehead or the brain. When a person is trying hard to recall an event, there is a tendency to put the hand to the head, as in the famous attitude of the philosopher. The same is true of the sense organs. In thinking of something seen, heard, or tasted, there is a tendency to locate, usually with the hand, the sense organ concerned. Likewise, in attention to what a particular muscle has done or should do, there is a tendency to locate it by touching this particular limb or organ. Think of soft velvet, and you will observe a tendency to feel with your fingers in the absence of the cloth.

One of the most interesting series of illustrations of these movements is to be found in so-called muscle reading, where the artist in this form of mind reading has become skilful in guiding himself by the unconscious movements which accompany attention to the flow of images. These movements seem peculiarly mysterious because, often, they are as unconsciously apprehended as they are unconsciously expressed, and our mind reader is conscious only of a sort of intuition about what to do, and often recognizes the act only after it has been per-

formed. This is illustrated in all forms of mind reading which involve contact, as in leading a person to find a hidden object. However, guidance need not come through contact; it may come through any of the senses which convey information about the unconscious movement of the individual of the group. Where there is a group of persons, or an audience available, the sounds resulting from all sorts of movements expressing changes of attention become an adequate guide, so that the stage performer can walk out into an audience and find a hidden object entirely from such cues.

The motor theories. — Such unconscious movements, by analogy and survival, enter into all our normal activities of the higher mental processes and furnish a large part of the basis for a motor theory of the perception of rhythm and the motor theory of perception, conception, and thinking in general. We have already seen interesting illustrations of these, as in the illusion of weight, where we found muscular adjustments indicative of the movement of attention so marked that they were regarded as the cause of strong and persistent illusions.

Many of these accessory movements are regarded as overflow effects resulting merely from spread of stimulation of a specific set of muscles; but ordinarily, we find in this "spread" a remarkably fixed application of the principle of analogy, so that in the hundreds of traceable movements involved in thinking, *e.g.*, of your telephone number, each and all may be traced back into this most intricate network of surviving movements on the principle of analogy. Thus, the wrinkling of the forehead, the biting of the teeth, the pressing of the feet, the in-

hibition of movement in stopping to listen and holding the breath, may be regarded as accessory movements, having in the past been essential for the functioning of the sensory or motor organs. Even though they do not now serve a direct purpose, these survival activities may be regarded as facilitating attention by favoring a general attitude of mobility and tension. Indeed, some of these movements are so clearly indications of attention that we measure the effectiveness of a speaker by the quiet in the room and pronounce the audience as inattentive when there is a beginning of rustling and relaxation.

Action of glands. — There is another class of movements, far more significant, but perhaps more difficult to observe because they take place in the action of the internal organs of secretion, circulation, aëration, and metabolism. It is safe to say that the concentration of attention is correlated with an extremely complicated system of secretions, not only in the ductless glands, but by stimulation from these, throughout the entire system of circulation and metabolism. To concentrate attention means, for example, to set up a rush in the circulation in the brain somewhat in the same way as, when a fire occurs in a small village, more steam is turned on in the power plant to get pressure. The increased and focalized brain activity which corresponds to attention is manifested in modifications of the pulse rate, breathing, and temperature, which are outward signs of contractions of the arteries, increased action of the heart, and increased chemical activities from the internal secretions which may be roughly proportional to the intensity of the mental effort experienced.

Indeed, we may say in general, that there is no exertion of attention without correlated bodily expression. Some of these movements facilitate the apprehension of the object, others are accessory to these, and still others are sequels in action; but by far the largest mass of muscular movements are survivals by analogy to movements that have been useful in the past. In this idea of accessory, sympathetic, and survival movements in attention we find the key to the behavior in all mimicry and gesture.

CHAPTER X

MENTAL IMAGES

In Chapters II to VIII we have examined the experience of presentations through the senses as they occur when the object stimulates the sense organ. Our problem in the next few chapters is to examine mental life in the process of re-instatement, re-presentation, re-production, and pre-production of past and future experience.

Exercise. — *With eyes closed, visit in memory and imagination the yard of a familiar home. Count the windows of the house, pick a flower and hold it to your nostrils, eat a bit of luscious fruit, and listen to the singing of the birds. — Did you see? Hear? Smell? Taste? Feel muscular strain? Pressure? Warmth? Number your answers in the order of the clearness of the experience.*

Nature of images. — Mental images are the mental representations or pictures of things not present to sense. When an object is present to our senses we *perceive* it; when, in its absence, we recall or imagine it, we may *image* it. The presentative experience is a percept; the representative experience is an image. The content of memory and imagination consists primarily of mental images of things, situations, events, or traits, as recalled or imagined. This is a general tendency of all representation, even the memory or imagination of abstract facts, such as happiness, goodness, or truth; for we have a tendency to represent these abstract qualities as embodied in

concrete situations, such as exhibitions of happiness, goodness, and truth.

The child may be several years old before he becomes aware of the fact that he has percepts of color, form, tone, or taste. So the youth may even reach the class in psychology before he discovers that he lives in a world of mental images; yet this imagery constitutes the main bulk of his mental life. Even scientific men were not aware of the existence of mental images until about half a century ago. Sir Francis Galton first wrote, in 1875, to scientific men and asked them if they had visual images; and, finding that they did, he sent out another inquiry asking if they had images of sounds, tastes, and odors. This shows that, although these images may be very realistic when called to our attention, we are not ordinarily aware of the images as such, but of objects; just as in perception we are not aware of the percept but of the object. Verify this last statement by looking at the furniture in your room and then recalling it with eyes closed.

Function of images. — The purpose of the image is to make memory and imagination complete, immediate, and realistic, — to reinstate the original experience in lifelikeness, and bring into actual experience the form, color, odor, temperature, weight, etc., of the absent object. Without imagery we should be able to recall only the abstract ideas and the names for objects, and it is doubtful if we could recall even the names for things without verbal imagery of the things; for names are themselves imaged as seen, heard, or felt. Imagery, then, gives us the power to pass in mental review things of the past or things

to come for examination, for enjoyment, and for guidance in our daily life. It gives continuity to experience in that the past and the future may be lived into the present realistically.

Difference between percept and image.

EXERCISE. — *Look at this book and see the shape of the page, the style of print in this paragraph, and the punctuation after the word "exercise," and observe that the whole percept is clear, relatively complete in detail, sustainable for a long time, and under control so that you may turn from detail to detail as you please. Now close your eyes and recall in turn these impressions of the book. Write down how the image compares with the percept in (1) vividness, (2) minuteness of detail, (3) stability, (4) control of the point of view, (5) correctness or fidelity, and (6) consciousness of the presence of an object.*

The differences here observed are characteristic of the fundamental difference between presentation (perception) and representation (memory and imagination).

The attributes of the image. — The image has the same attributes as the sensation; namely, quality, intensity, duration, and extensity. Just as we explained all things in sensory experience in these four terms, so we find that all that we can remember or image of the material world may be accounted for in terms of these four attributes of the image. Just as we are able to identify only a small portion of sensation in our rich sensory experience, so we are limited in our ability to isolate and become clearly conscious of the image at all stages in our very rich representative experience. The reason for this in both cases is that the sensation and the images operate so naturally and constantly that ordinarily we do not notice them: we notice the object, not the medium of its

construction. Yet it is in terms of sensation and image that we represent our entire experience of the outer world. The image is the thing that is present in consciousness of things past and of things to come; also, in large part, of things present.

The rating of imagery.[1] — This exercise is devoted to a test of the capacity for *vividness* of imagery. It is a distinct exercise in introspection. It is best to keep the eyes closed as you introspect.

Fix clearly in mind and use as consistently as possible the following scale of degrees of vividness:

0. No image at all.
1. Very faint.
2. Faint.
3. Fairly vivid.
4. Vivid.
5. Very vivid.
6. As vivid as in perception.

Answer the following questions by writing after the number of the question the number which denotes the degree of vividness characteristic of your image.[2] Prepare a table for this purpose. Introspective notes to supplement the numerical answers are very desirable.

[1] Extract from the chapter on Mental Images in the author's *Elementary Experiments in Psychology*.

[2] To some students this exercise will be entirely too easy; to others, equally bright, it will seem like an impossible task. The reason for this difference lies in the fact that one person may have such vivid imagery that it is as easy for him to answer the first question as to say whether or not he sees a rose which is held before his open eyes, while to another person the task seems unreasonable; for, with the best effort, he cannot see the slightest evidence of any concrete image, nor does he know what it is to have such an image. These are extreme types, between which normal types range. The student who finds difficulty should not be discouraged. The aim of this exercise is not to develop imagery, but to test the actual normal capacity.

I. *Visual.* — Can you image (1) the color of a red rose, (2) the brightness of a white teacup, (3) the form of the rose, (4) a moving express train visually, (5) simultaneously, a group of colors in a bunch of sweet peas, (6) a comparison of the color of cream and the color of milk, (7) the color of the rose, steadily for ten seconds?

II. *Auditory.* — Can you image (1) the sound of the report of a gun, (2) the characteristic tone-quality of a violin, (3) the tune of Yankee Doodle, (4) the loudness of a very strong violin tone, (5) the rhythm of the snare-drum?

III. *Motor.* — Can you image, in *motor terms*, (1) yourself rocking in a chair, (2) the movement of a waterfall, (3) aside from the actual inceptive movements, a very high tone, (4) an inch, (5) the weight of a pound of butter?

IV. *Tactual.* — Can you form a tactual image (1) of the pressure of velvet, (2) the size of a nickel, (3) the flow of water against the finger?

V. *Olfactory.* — Can you image (1) the odor of coffee, (2) odors from a meadow?

VI. *Gustatory.* — Can you image (1) the taste of sugar, (2) the taste of an apple?

VII. *Thermal.* — Can you image (1) the coldness of ice cream, (2) the warmth of hot tea?

VIII. *Pain.* — Can you secure a sensory image of the pain from the prick of a pin?

Compute the averages for all the answers in each of the experiments I to VIII, and plot a curve showing the relative vividness of the image in each of these senses.

Such factors as vividness, stability, and integrity of the image do not necessarily vary together. An image may be very vivid but flitting; it may be complete but faint. For a full study of the capacity, the above questions might be repeated and answered in turn with reference to each of the variables in the image. This same exercise might be used for the determination of such factors as the stability of the image, completeness of the image, or effort in producing it. In such cases, words representing stability, completeness, effort, etc., would be substituted for the word vivid in the scale; *e.g.*, no image, very fluctuating, fluctuating, fairly stable, stable, very stable, as stable as in perception.

EXERCISE. — *This rating has been a clear-cut exercise in systematic introspection, exhibiting the advantages and disadvantages of this method. Write out a comprehensive list of (a) the advantages and (b) the shortcomings of this method.*

Imaginal types. — Compare your chart with those of other persons and you will be surprised at the difference. Argue about it and you will discover remarkable things about imagery. Look into it as into a mirror and see how truly it characterizes your consciousness of the outer world. Evaluate the realism of your memory and imagination in terms of this chart as compared with the actual sensory experience. Consider whether these facts have any bearing on your vocation, interests, temperament, and emotions.

It can be readily understood that the world seems different to different individuals according as they represent it in memory and imagination as something seen, something heard, something touched or smelled, some-

thing experienced through all the senses, or, in an extreme case, without any images at all. Such differences exist. Some of the most intelligent men maintain that they employ no imagery, while a more than equal number maintain that their imagery is as complete and as effective as the original perception. A representative of each of these extremes seems like a monstrosity to the other. Between them normal persons distribute gradually with a bunching about midway. But there are also significant individual types. In most of us, the visual image dominates; *i.e.*, we are visualizers. Many have a dominant motor imagery: they are the motiles. Others have more conspicuous auditory imagery: they are the audiles. Then there are combinations, such as the visual-motor and the auditory-motor. We also speak of high and low imagery types. Although there are no pure types, the tendency toward types is conspicuous and the distinction is helpful. Normally all senses function in imagery, and the rank of each tends to be approximately that of frequency in perception.

The visual image ordinarily comes first and easiest, simply because most of us habitually think of objects as seen. The several coöperating images of the same object appear in different order. In the recall of a handshake, *e.g.*, the situation may first be seen and then followed up by motor, tactual, and temperature images of the shake, and finally perhaps of the auditory image of the spoken greeting, although these are all represented as happening in the same instant. The motor image is most difficult to identify, partly because we have formed the habit of translating motor space into visual space in perception,

and largely because the motor images are nearly always accompanied by sensations of actual or inceptive movements. Many persons have a prevailing verbal imagery; they observe the tag instead of the content of the package. Thus, in thinking of dogs, they may get a clear image of the word dogs, as seen, heard, or spoken, and no image of the animals may appear. Many have a

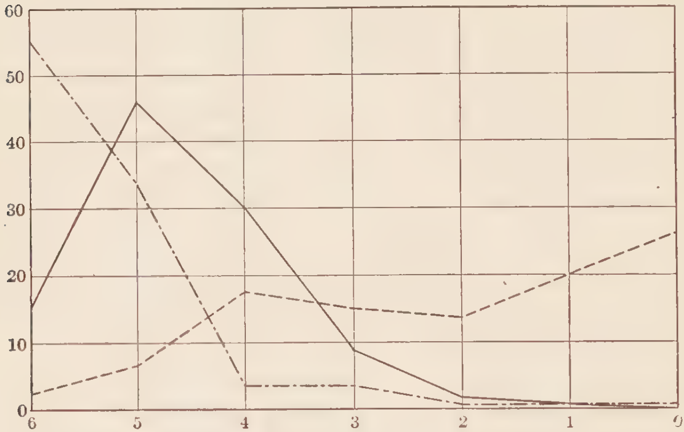


FIG. 16. — Distribution of ratings in auditory imagery

Solid line, unselected adults and children; dot-dash line, musicians; dash line, psychologists. Figures at left, per cent of cases; at the bottom, vividness of the image.

tendency to take that intermediate step in all imaging. Thus, in the above rating exercise, they image the word sugar readily and image the taste of sugar only after great effort. Quite often persons assert that they have no image of a particular kind, but a crucial objective test may reveal its appearance beyond question.

Fig. 16 shows the average rating on vividness of auditory imagery by musicians, psychologists, university stu-

dents, and children of the fifth and eighth grades. The distribution for the children of both ages was found to coincide so nearly with that of university students that, when smoothed, the distribution for unselected adults and children was represented in the same curve. After making due allowances for sources of error, the legend of this curve remains striking. Musicians rate themselves high in auditory imagery; psychologists, as a class representing the scientific mind, rate themselves low. Unselected adults and children tend to follow in a middle curve. It is interesting to find that musicians regard imagery as essential to a real appreciation of music as do also most psychologists, and that psychologists differ in opinion as to whether they have never had this gift or have suppressed it by their devotion to abstract thought.

Most great composers can "hear out" music before writing it and again in reading the score, before going to an instrument. The player often plays by an imaged standard. The listener who can relive the music of yesterday has greater resources than the one who merely recalls abstract forms. Motor memory plays an important rôle in music in that it is in large part the stuff of which musical emotion is made.

Stories are told of artists who, after having seen a sitter for a portrait for a single time, could pose him through mere imagery as often as desired. While imagery is essential in all realistic art, it is peculiarly helpful with those arts which create form.

The significance of imagery. — Superior imagery is not necessarily a mark of intelligence. The prominence of images seems to vary quite independently of the degree

of intelligence. But the type and the degree of imagery profoundly affect the kind of intelligence. Compare, for instance, the musician who recalls and imagines music in abstract terms with the musician who hears it as effectively in recall or in composition as if actually performed. Compare the artist who represents his subject in exact detail and in the same position as long as necessary with the one who cannot visualize. Compare the child whose representations are abstract, cold, and barren, with the child who relives an experience and anticipates the future vividly in imagery quite as realistic as a perception. Such comparisons amount almost to a comparison of the blind and the seeing, or the deaf and the hearing. Capacity for precise visual imagery is undoubtedly one of the marks of talent for painting, architecture, and sculpture; and musicians who have poor auditory imagery apologize for the defect. Similar vital bearings may be pointed out in countless routine occupations.

What sense shall vie with vision for prominence depends upon dominant interests and attitudes; or, shall we say, dominant interests in life are determined by native type of imagery? Has the musician turned to the world of sounds because he was born with good auditory imagery, or has he developed auditory imagery because he deals with sounds? Think out an answer to these and analogous questions for each of the other senses.

Evolution of the image. — In animal life the image is undoubtedly the primitive form of consciousness above the sensation level. In the consciousness of past experiences and anticipation of the future, it probably had the

same sort of immediacy as perception has for man. When the animal, which has encountered danger in a given position, again comes to that place, it reëxperiences the danger setting as a part of the actual present experience in that place; *i.e.*, the past is present in the form of an image. This image is not recognized as a memory of the past, it is merely an element of the present sensory experience.

Perhaps the homing instinct is guided largely by imagery. When the bird migrates from the Gulf to Canada and back, season after season, it is probable that he guides himself, not by conscious recognition of landmarks, but by the play of imagery creating the feeling of familiarity in the present sense experience of the guiding marks, such as the Mississippi River. From such primitive blending of past with present there has probably been a gradual evolution up to the present consciousness of isolation of image from other experience, and voluntary control of the image.

Development of the image. — It is generally believed that children employ imagery more than adults and that children picture actual objects and specific instances, while adults think in terms of symbols of objects, usually words or generalized notions. The adult undoubtedly does more abstract thinking than the child, but it is conceivable that the adult may also have better imagery than the child, because he has wider experience to draw from and may have developed precision in this imagery by use or training in a narrow field. However, the vast mass of occupations tend to dwarf the development of imagery. The way to develop imagery is to give it something to do, — to use it. The best proof of the possibility of developing

imagery by use is found in the case of those who are early deprived of the higher senses and are forced to represent vital situations with extreme vividness and accuracy in such senses as pressure, strain, or odor, as in the case of Helen Keller. Training in discriminating observation results in corresponding development of precision in the image.

CHAPTER XI

ASSOCIATION

EXERCISE. — *Have some one time you to find how many words you can speak in seven seconds, starting with a keyword called by your assistant. Speak as fast as possible, taking the words in order as they come to mind without thinking! Practice until you can speak at least nine words within the time set. Record five such trials with explanatory comments.*[1]

In this exercise you observed, among other things, that what came to your mind was a procession of images in various senses; that there was a scramble among these images for recognition; that they came much faster than you could recognize or speak them; that it was possible for you to go back and fill in many images of the procession which served as connecting links, although you did not have time to mention them; that there was a natural association, or bond, from image to image; that, although by direction you spoke faster than you could think and did not try to select words that were related, natural relationships exist for every link in the chain; and that in each "story" you unconsciously and irresistibly revealed something of yourself.

[1] *Example:* "Keyword, *friend:* mine, Mame, Carolyn, Baraboo, Wisconsin university, Duffield, California. (1) Mine came from the frequent association of the words 'friend of mine.' (2) Mame is one of my dearest friends and this name was probably favored by similarity of sound (mine, Mame). (3) Carolyn was a chum of Mame and myself. (4) Carolyn lives in Baraboo. (5) Baraboo is in Wisconsin. (6) Our friendship was formed in the university. (7) Duffield was the portliest and most good-natured of our gentlemen friends at that time. (8) Duffield lives in California."

Nature of association. — Such observations may be summed up in the statement that objects, events, situations, ideas, feelings, and acts are always experienced in some relation; and, when we are conscious of any part in that relation, other parts tend to follow: those factors that have been present together, or in succession, or have some common elements, tend to recur together.

Let us call the key word, or other starting point, the "cue." Any mental process may serve as a cue which draws in its associates in this manner. Every mental cue tends to reinstate its former associates. This is the principle of association which is the groundwork of all experience. It will be well for us to observe it in a few typical situations, as in perception, memory, imagination, and feeling.

Association in perception. — In perception impressions get their meaning by being set in past experience through association. Consider the first time you saw an airplane. The cue for the perception lay in certain visual sensations. These were "set" in numerous associated images and reactions — flying, bird, wings, power, danger, sport, speed, height, invention, genius, a ride, skill, gravity, etc. The mental act of seeing the airplane for the first time called forth these and numerous other associates which gave meaning to the percept and thus became tied up with it. They flocked in instantly and irresistibly the moment you "saw" the plane. Each of these associates was dragged in through some bond (association) formed in previous experience. Each, being thus welded as links into a new chain beginning with this sensory impression, there-

after remains associated with every other. The whole experience may have occupied but a moment, and it is only as you stopped to review the experience that you became clearly conscious of any of them; yet scores of them were present in the meaning — airplane. In this manner each new experience is tied up with past experiences through this tendency to set each new experience in its natural association with our experience as a whole, directly or indirectly. Perception always involves association.

Association in memory. — The same thing happens in memory, the process of reinstating former situations: some experience serves as a cue to bring its associates into consciousness. When we are able to identify this train of associates as meaning particular things or events which we recognize as a part of our past, we have memory.

Recall the front door in your childhood home, and observe this act of memory carefully. Instantly, upon this request (cue — something seen) there flashed into your mind, perhaps, the image of the door of your room. This image of a door was followed at once by the image of the door of your home with fragments of the house, garden, folks, voices, movements, special pleasures or sorrows, etc.; but, by special attention, you soon rejected all the accessories and concentrated your mind on the clear and correct image of the door. All this, perhaps, happened in "the twinkling of an eye." Close observation at the time would have revealed in you signs of feeling and inceptive tendencies to action appropriate to the occasion, all of which were again unconsciously

woven into the fabric of the associations. How did you remember this door at will? Simply by following trains of associations until that image appeared which you "felt" was the right one. Perhaps the process was so automatic that you were aware of the right image instantly and were not conscious of the setting or the steps involved any more than when your eyes fall upon the door in front of you now and you instantly perceive it as a door. Yet many links led the way even so. It is only when we stop to analyze such common acts that we become aware of the complexity of the process and the orderliness in the operation of the laws of association in such a simple act of memory.

Association in imagination. — Imagine that the book you are reading is printed in all the colors of the rainbow and note carefully the process of your imagination. A good observer may find something like this: the request serves as a cue which may bring to consciousness two images — the book and the rainbow. The colors of the rainbow may appear in their true order, the book in its true size. The problem, then, is to satisfy your feeling with the imaginary arrangement of the colors in the type. Many possibilities present themselves (associated images) as the result of following different lines of associates from the cue. These are rivals for recognition and favor. Finally one is recognized as best suited for your purpose. You project that upon the page, real or imaged, and throw the competitors into the dim background. Possibly you still vacillate; then the rivalry persists in action on the page. Or perhaps in your fertile imagination you recognize in clear succes-

sion one arrangement after another as worthy of your approval. The mechanism of imagination then is association. Percepts, images, ideas, and feelings are the materials associated.

Association in thought. — Think out the answer to this question: Does the color of the rainbow serve any purpose? Observe your mental process in this act before reading further.

What happened? Perhaps the image of the rainbow came to mind and then followed images of examples of purposes, some relevant and some irrelevant, such as a bridge, a work of art to give pleasure, protective coloration in animals to attract mates, and the like. The difficulty lay in finding, among such examples, something that might be like the rainbow in serving a purpose. Then arose a succession of images of things in nature that give pleasure. After following up chain after chain of such associations and reviewing many of them, you gradually arrived at a conviction, which expressed your judgment, either affirmative or negative. Thinking, then, is a process of association — the process of solving problems by following different chains of associations in search of a conviction — truth.

Association in all mental life. — In this manner association is the bond of experience, conscious and unconscious. It is the groundwork of all mental life. Instinct is the unconscious association formed in the life of the species; habit is the unconscious association formed in the activities of the individual; feeling is the mass formation of undifferentiated associations; impulse is the breaking out of the associations into action

under the sway of feeling; imitation is a blind following of associations with behavior of others; will is association controlled by selective attention; animal thinking is mere association. On the other hand, deviation from the normal is a disturbance of association; hysteria, altered personality, insanity, are dissociations or false associations.

Primary laws. — Since the time of Aristotle much effort has been spent in an attempt to classify the various kinds of association. The commonest kind of classification is three-fold: contiguity, similarity, and contrast. But the general tendency of the present time is to subordinate all under one head, contiguity, or the law of reinstatement: things that have been associated in any way in previous experiences tend to reinstate themselves together. This embraces all kinds of recognized relationships; such as contiguity in time — flash of lightning, thunder; contiguity in space — door, door-knob; cause and effect — pin prick, pain; purpose — knife, cut; synonyms — glorious, grand; similarity of all conceivable kinds — similarity of purpose, of appearance, of meaning, of operation, and an equal number of opposites, or contrasts. In brief, the law of reinstatement is a recognition of the fact that the mind tends to integrate in a new situation those common elements which were experienced together in former related situations. What shall be reinstated in a new experience depends in part upon what kinds of bonds exist. The primary laws of association denote what *kind* of relation exists.

Secondary laws. — In experimental psychology a more specific formulation of laws in terms of force of

the association has gained recognition. The chief of these are: (1) *primacy:* other things being equal, the association first formed will prevail; (2) *recency:* other things being equal, the most recently experienced association will prevail; (3) *intensity:* other things being equal, the most strongly experienced association will prevail; (4) *frequency:* other things being equal, the most frequently experienced association will prevail; (5) *emotional congruity:* other things being equal, that association which is most congruous with present feeling will prevail. This last is not as rigid as the other forms; it embraces a variety of conditions which modify the mental set or attitude of the individual.

The secondary laws of force operate within the primary laws of kind. Thus, contiguity in time is effective only as it has been experienced primarily, recently, intensely, or frequently. The same is true of all other kinds of contiguity, similarity, or contrast.

EXERCISE. — *Secure three series of associations as in the above exercise, and indicate at each stage what secondary laws were operating.*[1]

Norms of frequency in association. — The following table of associations is typical for unselected normal persons. The word in italics at the head served as a cue. It was spoken by the examiner, and the observer was required to speak in response the first word that came to his mind. The aim was to respond as quickly as possible. The reaction time of each response was recorded.

[1] It will be observed that sometimes more than one law operates and very often the connection must be traced through images in the train of associations which were omitted in speaking.

It is here observed that for each cue word there are certain natural associates which are most frequently chosen.

[1] *1. table*	*2. eating*	*3. short*	*4. wish*	*5. beautiful*
267 chair	170 food	279 long	197 desirable	113 pretty
76 wood	166 drinking	168 tall	51 hope	86 handsome
75 furniture	46 bread	136 small	19 good	73 nice
63 eat	44 hungry	24 stout	19 boon	66 ugly
56 cloth	31 dinner	20 man	18 happiness	64 lovely
40 dishes	27 chewing	18 length	18 have	42 flowers
36 stand	23 good	15 person	15 granted	40 grandeur
34 eating	21 table	15 little	14 get	29 woman
29 food	19 hunger	13 height	11 fairy	27 homely
26 dinner	17 sleeping	11 dwarf	11 gratify	24 girl
17 cover	12 satisfaction	11 girl	10 long	23 scenery
14 board	11 nourishment	10 distance	9 luck	10 picture
13 leg	11 masticating	9 stubby	8 ask	16 nature
11 desk	11 meat	8 quick	8 like	16 sky
10 legs	10 digestion	8 stick	6 health	16 pleasing

The association reaction in psychoanalysis. — In reactions like these, the observer, if prompt, may reveal his mental content in spite of his will or intentions to the contrary. Thus it is found that it is possible to classify persons of different occupations, education, criminal tendencies, and talents by such sampling of the natural but rushed association. Perhaps the most interesting use of the association reaction is that introduced by Jung in the attempt to discover the cause of certain mental diseases for the purpose of cure. Here is a man, for example, who is suffering from melancholia and sits around useless and distressed because he is so "unworthy." Given a list of words to which to react, it was observed that when he came to the word "short" he hesitated to give one of the most natural responses, such as *long* or *I*; he took a long reaction-time, showed

[1] The number shows how many times this association occurred in 1000 cases. From *American Journal of Insanity*, Vol. LXII, Nos. 1 and 2, 1910.

embarrassment, and responded with an irrelevant word. It was found later that the associate he had evaded was *I*. A number of related responses gave evidence of the same "complex."[1] The physician drew the conclusion that this insanity was due to the fact that this man was small of stature. He had come to think of himself as unworthy, incapable, socially undesirable, insignificant, etc., and these thoughts and feelings had expanded in vicious circles resulting in a feeling of helplessness, despair, and negativism which resulted in melancholia, all coming from the idea "small of stature" which he himself did not think for a moment had anything to do with his present deplorable condition. The early consciousness of shortness, the physician says, had resulted in a repression; *i.e.*, the unconscious concealment of an undesirable association or fact.

It has been observed in certain types of cases that the cure consists in laying bare, through analysis and reasoning with the patient, the fact that his present disease is nothing but unfortunate associations with the simple fact, *e.g.*, that he is short. Here the whole disease, which is a rather common one, lay in a chain of false associations; and the cure lay in retracing and clearly revealing the falseness of these associations.

The association reaction in the detection of guilt. — An experiment has been devised by which it is possible to detect whether a person knows or does not know a certain thing, or is guilty or not guilty of the act. Suppose you have in a distant room two boxes, one contain-

[1] A complex, as the term is used in medical psychology, is a persistent group of associations that lead to mental distortion; hence, dissociation.

ing a revolver and one a frog, and a man is asked to step into the room and look into one box only and you undertake to determine by means of the association test which box he looked into. You take his reaction-time for association in a list of words, such as house, tree, print, business, fear, green, trigger. Green and trigger are relevant words — one for each box. If, for example, he has seen the revolver, the natural association for trigger would be revolver. He catches himself, thinking that saying revolver would give him away, so his reaction-time is lengthened by the time taken for thinking and he responds with a more distantly associated word, *e.g.*, "trap." The certainty of the finding is increased by using a number of relevant words in a long list of words. Closely observed, it would also be seen that he experienced embarrassment when the relevant words were spoken. This in itself is enough to solve the problem.

The physical basis of association. — We have thus far discussed association from the mental aspect, or experience. But association is a psychophysical process — mental-physical. Indeed it may be described from either the mental or the neural side. The two are, as it were, aspects of the same whole. Since association is the basic process in all mental life; and, since it cannot be explained or understood fully without reference to the physical aspect, we shall now digress for two chapters to bring up the physiology of association, approaching this subject through a study of reflex actions.

CHAPTER XII

REFLEXES

If we proceed upon the assumption that the brain is the organ of consciousness, it may be interesting to know what an animal can do without a brain. It has fallen to the lot of the frog to demonstrate this most frequently.

Spinal reflexes in the frog. — A frog is said to be reflex or pithed when its brain has been separated from the spinal cord. This may be done by severing the cord at the back of the brain and removing the brain with a probe. A simpler way is to decapitate. If we then suspend the animal, so that its limbs are free, we may observe that, as long as the animal is not disturbed, it will hang relaxed, still, and inert without breathing, swallowing, croaking, or even a twitch of muscle — in every respect as if it were dead. It has no power of starting any movement of its own. With the frog thus prepared, we may perform the following experiment: [1]

Pinch a toe: the toe withdraws. Pinch another toe: that toe withdraws. Pinch or prick the frog at any place and the appropriate defense or withdrawal action will follow. Put a drop of diluted acid on the shank: the appropriate limb properly brushes it off. Place a drop of acid on any part of the body: in every case

[1] This experiment must be performed either as a demonstration in class or by the individual student. Mere reading about it would be inexcusable and of only superficial value.

the appropriate wiping movement takes place. Heat a nail and touch different parts in the same way, as in pinching: appropriate results follow. Send a light electric shock to different parts, as in pinching: the appropriate responses follow. Vary the force of the shock: the magnitude of the movement increases with the force of the shock; larger and larger groups of coördinated muscles are brought into action. Send shocks through the back at the rate of ten or fifteen per second: the whole animal becomes rigid. This rigidity is called tetanus.

What have we learned from the experiment? We have observed that, if undisturbed, the frog makes no movement and remains quiet as if dead; but, when stimulated, it will behave with extraordinary alertness and appropriateness to all the stimuli tried. It is sensitive to mechanical, thermal, chemical, and electrical stimuli. The responses are prompt, specific, appropriate, and adequate. They vary with the location of the stimulus and the force of the stimulus, but not with the kind of stimulus. A repeated succession of stimuli produces tetanus.

Yet if our assumption be correct, which we may grant for the present, the reflex frog felt no pain, pressure, heat, injury, or shock; no discomfort, no unpleasantness, or suffering of any kind as a result of the stimulation: it was not aware of anything. It did not initiate or intend any movement; it was an automaton; *i.e.*, it behaved in a mechanical way, like a jumping jack; yet the performance had all the appearance of being sensitive, reasonable, intended, and felt.

Reflexes in other animals. — This principle of action may be observed in all animals, including man. A dog, whose spinal cord has been severed in the same way, if touched lightly, as by the crawl of a flea, will at once balance itself on three legs and paw off the stimulus appropriately with the fourth. Some of the cold-blooded animals, even the frog, may be cut up into segments, and each segment may for a while perform the reflexes of that section of the spinal cord which is left intact. It was once observed that, after an execution, a decapitated man's hand came up and brushed off a tickling stimulus on the breast; but in general it is easiest to demonstrate these reflexes in the lower animals, because the general effect of the shock of the operation is not so great on them.

Reflexes from the lower brain centers. — According to best authorities to-day, the cortex of the cerebral hemispheres is the organic correlate of consciousness. By removal of the hemispheres we shall then remove all possibility of consciousness; such as sensation, memory, feeling, and will. In the reflex frog we removed the whole brain. The complete central mechanism for the reflex actions observed was therefore in the spinal cord.

The next higher centers, the medulla oblongata, the optic lobes, and other ganglia between the spinal cord and the hemispheres of the frog, are each proved by experiment to contain a mechanism for the accurate execution of movement in response to definite stimuli and for coördination of more complex processes. Thus, with the medulla the animal swallows; with the medulla and cerebellum together he jumps, swims, and turns

over from his back; with his optic lobes, he croaks when pinched.

"A frog which has lost his cerebral hemispheres alone is by an unpracticed observer indistinguishable from a normal animal. Not only is he capable, on proper instigation, of all the acts already mentioned, but he guides himself by sight, so that if an obstacle be set up between him and the light and he be forced to move forward, he either jumps over it or swerves to one side. He manifests the sexual instinct at the proper seasons and discriminates between male and female individuals of his own species. He is, in short, so similar in every respect to a normal frog that it would take a person very familiar with these animals to suspect anything wrong or wanting about him; but even then such a person would soon remark the almost entire absence of spontaneous motion — that is, motion unprovoked by any present incitation of sense. The continued movements of swimming, performed by the creature in the water, seem to be the fatal result of the contact of that fluid with its skin. They cease when a stick, for example, touches his hands. This is a sensible irritant towards which the feet are automatically drawn by reflex action, and on which the animal remains sitting. He manifests no hunger and will suffer a fly to crawl over his nose unsnapped at. Fear, too, seems to have deserted him. In a word, he is an extremely complex machine whose actions, so far as they go, tend to self-preservation; but still a *machine*, in the sense that it seems to contain no incalculable element. By applying the right sensory stimulus to him we are almost as certain of getting a fixed response as an organist is of hearing a certain tone when he pulls out a certain stop."[1]

The manifestations here described of the frog are typical of all animals with a central nervous system. There

[1] From James, *Psychology, Briefer Course*, pp. 94–95.

are different levels of neural connections. The lowest and most firmly established is that of the spinal cord, which is the organ of the simplest reflexes; but the medulla, the cerebellum, and the lower brain ganglia have similar functions.

Reflexes in man. — We have drawn these illustrations in reflexes from a lower animal because it is possible to submit such an animal to exact experimental control in observation; but diseases, accidents, and surgical operations often present opportunities for verifying these observations in man. In general, it is found that man is built on the same plan of nervous organization as the higher animals; the principles of reflex action, which are demonstrated on these animals, hold in general for man also. They are, however, not so evident in man because they are so overshadowed by the prominence of the higher brain centers. While it is not possible to enumerate all the reflexes, and there are all kinds and degrees of transition from pure reflexes to higher forms of neural action, the classification recently made by Warren, Table I, is illuminating.

TABLE I.[1] HUMAN REFLEXES

A. *Purest — least subject to central modification in the adult*

'Pupillary' or iris reflex	Snoring
Ear twitching (controlled in some individuals)	Shuddering
	Starting (to sudden noise, etc.)
Hand withdrawal (to heat and pain)	Trembling
	Shivering
Mysenteric reflexes (operation of stomach and intestinal muscles in digestion)	Rhythmic contractions (in epilepsy, paralysis agitans, etc.)

[1] From Warren, *Human Psychology*, p. 110.

TABLE I. HUMAN REFLEXES—*Continued*

B. *Largely pure — subject to inhibition or reinforcement*

Winking	Hand twitching (to dermal pain)
Accommodation, ciliary reflex	Plantar reflex (to stimulus on sole of foot)
Eye-fixation and convergence	Great toe reflex
Hiccoughing	Vasomotor changes (blushing, paling)
Sneezing	Breathing changes (to specific stimuli and to onset of sleep)
Patellar reflex (knee-jerk)	Sudorific reflexes
Dizziness reflexes	Groaning
Yawning	Laughing
Vomiting	Cramp movements
Facial reflexes (to bitter taste, etc.)	Squirming
Salivation	
Tickle reflexes	

C. *Occasionally pure, more often centrally modified*

Coughing	Smiling
Swallowing and gulping	Wincing, etc.
Visceral discharge, etc.	Scowling
Functioning of sex organs	Stretching
Reflexes to odors	Convulsive contractions (to deep pressure and heat, to pricking and other dermal pains, and to visceral pain)
Gasping	
Weeping	
Sobbing	

D. *Pure in infancy, centrally modified in adult*

Sucking	Tugging (wrist reflexes)
Biting and grinding	Clasping (elbow reflexes)
Spitting	Reaching (shoulder reflexes)
Hunger and thirst reflexes	Kicking (knee reflexes)
Lip and tongue reflexes	Stepping (gluteal reflexes)
Vocal reflexes	Jumping (ankle reflexes)
Turning the head	Sitting up
Tossing	Bending forward
Grasping (finger reflexes)	Rising

E. *Posture reflexes*

Holding head erect	Standing
Sitting	Equilibration

The conditioned reflex. — Recent work, particularly by Russian physiologists, Pawlow and Bechterew, has

given us interesting methods of studying the function of the complex processes through the reflexes. One of these is known as the method of the conditioned reflex. It may be employed in many ways, the principal one being that of substituting one stimulus for another in the arousing of a reflex. Most of the experiments have been performed on animals, but they may be employed with man as well.

Let us take the salivary reflex as an example. The salivary reflex is to the effect that the awareness of food sets up a secretion of saliva. A capsule may be placed over the salivary gland in such a way as to collect the saliva as it is secreted. This saliva may be measured both as to quantity and rate of discharge. This furnishes a means then of recording how our reflex varies with numerous conditions which we may control.

Take, for instance, a girl who likes chocolate and observe her secretion of saliva by means of such capsule. Normally the secretion of saliva sets in when she begins to eat: when she is not hungry and is not in the presence of food, no saliva is secreted. Let her see a cake of chocolate and instantly the saliva will begin to flow; put the cake in her hand and the saliva will flow faster. Now, to get a conditioned reflex, we may adopt any signal or cue that we wish to substitute for the chocolate. Thus, we may in successive trials crumple a paper in the pocket and forthwith produce the piece of chocolate. The sight, touch, or taste of the chocolate produces the reflex, but the chocolate soon becomes so associated with the crumpling of the paper that the mere crumpling of the paper without the presence of anything to eat will

start the salivary reflex. The crumpled paper has, then, been substituted for chocolate as a stimulus. The sound of a bell, the flash of a light, a touch on the shoulder,— any signal,— might be injected into the reflex in this way, and we should always have a means of measuring the force of the substituted stimulus in the rate of flow of the saliva.

In the case just described the method of reward was used. Methods of punishment may be used on the same principle. Take, for example, the reflex of withdrawing a limb from an electric grid in response to an electric shock. By associating other stimuli with the electric shock we may establish the conditioned reflex as above. Suppose that you wish to measure the form discrimination of a dog. Let the dog stand on a grid through which an electric shock may be sent through its front feet by pressing a button. The shock causes a reflex jump. Now suppose that in a series of trials you flash a circle and a square and give the shock simultaneously with the circle; but with the square no shock is given. If the dog can recognize the differences in the shape, he will soon learn that no shock comes with the square; whereas it always comes simultaneously with the circle. After some practice on both, the dog will respond with the reflex to the circle whether the shock is given or not, and will not respond to the square, showing that he sees the difference. The difference in form may then be gradually reduced in successive experiments until we find the dog's least perceptible difference for the form.

This is perhaps the fundamental type of method in the so-called objective psychology or behaviorism. It

has obvious limitations but promises much in the way of a rigid objective check in psychological experiments. The method can also be used in simple observation, as, *e.g.*, in the observation of likes or dislikes for any particular object or situation by a systematic observation of the reflexes of the inceptive smile or the inceptive frown.

After this exhibit of neural action, we are prepared to recognize the great rôle of unconscious action in all experience and behavior, and are ready to inquire eagerly into the nature of neural action — the function of the nervous element, the nature and behavior of the nerve impulse, and the theory of the physical basis of association, which we shall now review briefly in the next chapter.

CHAPTER XIII

NEURAL THEORY

Structure of the neurone. — The unit of the nervous system is the neurone, which is a sort of battery with its connections capable of receiving, generating, and transmitting nerve impulses. The nervous system, as a whole, consists of approximately ten thousand millions of these batteries with their connections so arranged as to constitute countless courses for nerve currents. (For illustrations of neural structures see Appendix.)

The typical neurone consists of a cell body and its branches. The structure of a particular neurone is determined by its function and location. The vital part is the nucleus in the cell body. This is embedded in a substance called cytoplasm, which contains a granular substance through which nerve fibrils radiate into the branches. The branches are of two kinds: the dendrites, which carry nerve impulses into the cell body; and the axon, which carries the nerve impulses out of the cell body. The dendrites are short, tapering, tree-like branching projections from the cytoplasm. There is ordinarily but one axon. A cross-section of this reveals a structure similar to that of our common lamp-cord: a central cable of fibrils — the axis-cylinder serving as a conductor; a white, fatty insulating substance — the

myelin sheath; and a capsule, serving as a protection and container of the more delicate parts. The axis-cylinder may be of any length from a fraction of a millimeter up to the distance between the tip of the toe and the spinal cord.

FIG. 17. — *A–D*, showing the *phylogenetic* development in a series of vertebrates; *a–e*, the *ontogenetic* development of growing cells in a typical mammal. In both cases only pyramidal cells from the cerebrum are shown: *A*, frog; *B*, lizard; *C*, rat; *D*, man; *a*, neuroblast, or young cell, without dendrites; *b*, commencing dendrites; *c*, dendrites further developed; *d*, first appearance of collateral branches; *e*, further development of collaterals and dendrites; *ax*, axones; *de*, dendrites; *cl*, collaterals. (Angell, after Donaldson and Cajal)

The general structure of the neurone is the same in all animals; but the higher the animal, the more pro-

fuse is the arborization, or branching of the neurone. This difference and the order of growth in the development of the neurone are illustrated in Fig. 17.

Grouping of neurones. — In the structure of the central and peripheral nervous system, the neurones are so bunched into ganglia or centers and joined through cables of nerve fibrils (axons) as to secure the most effective and economic functioning. Thus, nerve trunks are formed by laying cables composed of the axons of incoming (sensory) and outgoing (motor) neurones, as in the nerves to and from the spinal cord. The spinal cord is the grand trunk cable. Each of the complex structures known as basal ganglia, or lower segments of the brain, are bundles of neurones grouped in organized masses. The cortex (a thin layer of the surface of the forebrain) is made up of the cell bodies that have the highest function and is generally regarded as the organ of consciousness. The inside of the hemispheres is composed essentially of masses of axones (1) connecting the cortex with the periphery (projection fibers), (2) connecting each point in one hemisphere with the corresponding point in the other hemisphere (commissural fibers), (3) connecting each part of the cortex of one hemisphere with every other part of the cortex on the same side (association fibers).

Localization of functions. — Each part of the nervous system has its particular task or function. We have seen in the case of the frog what can be done with a spinal cord alone, and have noted that, for each higher segment in the central nervous system, more and more complicated processes are taken on. Each part of the

cortex of the cerebral hemispheres has its specific function; large regions are devoted to the motor connections and other regions are devoted to the sensory and the central processes respectively. Each of these is subdivided again and again. (See Appendix, Figs. 26 and 27.)

We can understand the general conception of localization if we think of the cortex as a switchboard, such as we find in a telephone exchange, in which every subscriber has a connection. Localization of function is, therefore, in physiological terms, merely the indicating of the locations of incoming and outgoing connections in the cortex. We do not locate mental processes. When we say, for example, that a certain area of the brain contains the visual center, we do not thereby locate sensations of color or space, but simply indicate in purely physical terms what part of the cortex is connected with the eye in such a way that if we are to see color and space the nerve impulse must pass through this part.

The nerve impulse. — The function of the neurone is to generate, discharge, and conduct nervous energy. The current that is generated and distributed by the neurone is known as a nerve impulse. The exact nature of the nerve impulse is not known, but, as in the case of electricity, we know something of its purpose, the laws of its generation and flow, and the results of its action. In the psychophysical organism, the nerve impulse serves purposes allied to those of the electric current in our telephone, lighting, and power machinery. It is generated in the cell body. When work is done in

the cell body, the nucleus "runs down." The cell has the power of self-charging.[1]

The speed of the nerve impulse in a nerve trunk is about one hundred meters per second: but, in passing from one neurone to another in a chain, it is much retarded. It flows in certain paths set by the organization of the neurone chain; but most paths are adaptable and change with new demands, and accumulating uses. The courses of nerve impulses have a complexity of organization adequate to account for the enormous complexity of both conscious and unconscious life.

The current that flows through a storage battery is a steady current, said to be direct; but, for lighting and power purpose, we ordinarily use an alternating current, *i.e.*, intermittent current, because it is more economical. This device of modern electricity is an imitation of nature's plan in the nerve impulse. In all muscular action, the movement is caused by the discharge of the nerve impulse from motor neurones into the muscular fiber. This discharge is not a steady flow but consists of pulsations or shocks, at the minimum rate that will secure steady action in the muscles.

This was illustrated in the tetanus or rigidity of the frog. The same might be illustrated even with a single nerve and muscle. The rate varies with the muscle that is to be sustained. If you hold your arm out straight and firm and apply a delicate hearing device, you may hear a faint tone of about forty vibrations

[1] "Nerve cells, like all other cells, lead individual lives, - they breathe, they assimilate, they dispense their own stores of energy, they repair their own substance waste; each is, in short, a living unit with its nutrition more or less centered in itself." (Sherrington)

per second, and the same may also be observed by electrical devices. This means that your arm is kept in steady suspense by a nerve impulse discharging at the rate of about forty impulses per second. This is the principle upon which all control of muscles rests; and, with some modification, it probably applies also to the central processes associated with consciousness.

Nature has anticipated electric devices in another way. Transoceanic telegraphy was made possible by the introduction of relay stations. This is the principle upon which the nerve impulse is transmitted through chains of neurones, even hundreds of thousands of links. Each neurone is an independent battery and all after the first in the chain may be regarded as relays. Each neurone in the chain does not merely transmit the current as a conductor, but the incoming impulse acts as a stimulus and each neurone in the relay in turn generates its own current. This accounts for the fact also that the nerve impulses originating in a single neurone may radiate out of thousands of associated paths, and each line of the divided impulse may maintain an adequate force.

Fatigue and age. — When a door bell battery runs down, it is not the clapper of the bell, nor the copper wire that is exhausted; it is the working chemical elements in the cell. So, in muscular fatigue, it is not the muscle, nor is it the nerve that is fatigued; it is the working part of the neurone that is depleted from the discharge of nerve impulses. The same principle holds for all kinds of physical as well as mental fatigue. The physical character of the effect of fatigue is shown in

Fig. 18. The nucleus has shrunk and become irregular; of the fresh store of chemical elements, only the ashes and cinders, as it were, remain. Rest reverses the process of

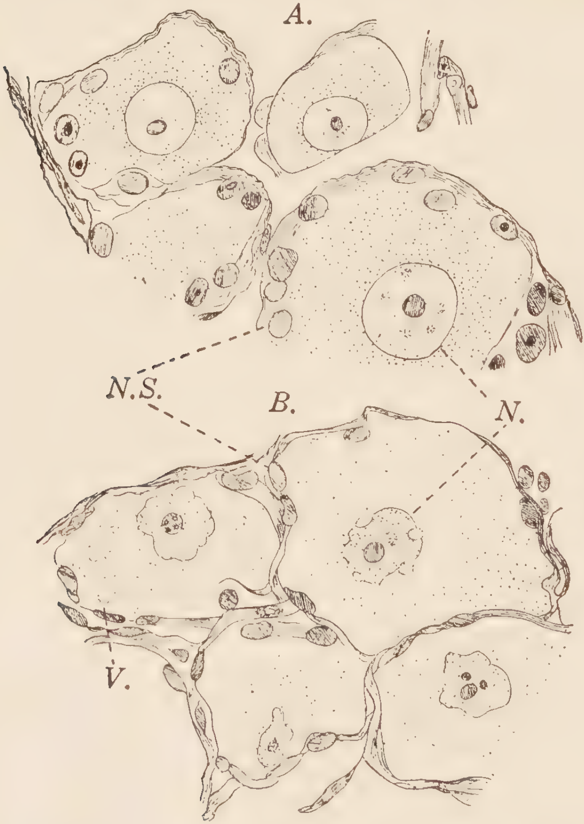


Fig. 18. — Evidence of fatigue in the nerve cell (Hodge). *A*, a fresh nerve cell; *B*, corresponding cells fatigued

fatigue and restores the nucleus normally within twenty-four hours. Age shows in the neurone in the same way as

fatigue except that the cell gradually loses the power of restoration. The characteristic condition of extreme age is shown in Fig. 19, in which 1 shows the cells from a young infant and 2 the corresponding cells from a man who died of old age. Many diseases affecting the nervous system take the same form of deterioration as in fatigue or age.

The reflex arc. — The elemental unit of action in animals that have a nervous system is called the reflex arc. In its typical simple form, the reflex consists of three processes: initiation of the nerve impulse, conduction of the nerve impulse, and end effect. Hence, we find the three elements of the arc: receptors in the form of sensory neurones in the sense organs, conductors in the form of nerve fibers and intermediate neurones, and effectors in the form of muscle tissue, into which the nerve impulse discharges and causes the response. The reflex arc must have at least two neurones, a sensory and a motor; but the typical arc has at least three, the third being a central neurone between the afferent and efferent. A reflex of this type taken by itself is said to be simple. Like pure sensation, the simple reflex is perhaps normally an abstraction, because the act can scarcely take place without

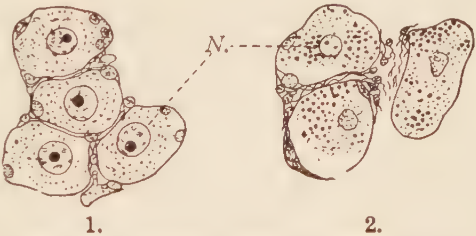


FIG. 19. — Evidence of age in the nerve cell (Hodge). 1, cells from a young infant; 2, corresponding cells from a man who died of old age.

disturbing associated neurones; yet it furnishes a true and serviceable concept for neural theory. From the simple arc we may trace a gradual development of coördination and compounding of these reflexes into more and more complicated patterns, even such as correspond to the most complicated neural processes.

The synapse. — The neurones, which are capable of being joined into circuits, are not grown together. Connections are made through mere contiguity or contact. The point in which two neurones come into contact may be thought of as a bridgeable gap, and is called a synapse. This form of free connection is a wonderful provision for plasticity; *i.e.*, possibility of forming new and varied connections by the raising or lowering of the resistance at any synapse for the purpose of opening or closing the circuit. If they were grown together, only fixed courses would be possible and, therefore, no learning could take place. In terms of the change in resistance at the synapse, we explain the plasticity in neural association; and, in terms of neural association, we explain the physical basis of mental processes.

Some characteristics of neural action at the synapse. — The exact nature of the mechanism of the synapse is not fully known. In general the nerve impulse behaves in the neural arc like an electric current in its circuit: it flows only in one direction, and takes the course of least resistance. A nerve trunk will carry the nerve impulse in either direction; but the synapse will transmit it in only one direction — from axon of one neurone to dendrite of another. By variation in

the resistance between adjacent neurones, a practically infinite number of "circuits," "paths," "neural patterns," or "neural arcs" may be formed. In passing through the synapse, the resistance encountered reduces the speed at this point, sometimes very greatly. There may be a summation effect: weak stimuli, any one of which would be too weak to overcome the resistance of the synapse by itself, may force the impulse through by repetition. There is a refractory phase in some reflexes; *i.e.*, under constant stimulation the synapse becomes resistant for a moment after the initial current. This results in the periodical movement in many reflexes, as in the scratching reflex. In this principle we shall probably find an explanation of the periodicity in many of the rhythms in mental life.

The final common path. — Sherrington calls the motor neurone in the reflex arc the "final common path," to indicate that the neurones which innervate a given muscle fiber furnish the only path to that effector. This effector may be energized from countless sources of irritation in the complex nervous system: but, to be effective through this particular effector, the nerve impulses must always switch in on this final common path. Thus, in the reflex frog, the right foot is used for wiping off all acid irritation within reach on the right side of the body; therefore, wherever they originate, the nerve impulses that innervate the right hind foot must discharge through some of the final common paths that lead to that foot. This conception is important for our purpose because, in the coördination and compounding of reflexes, the result must be interpreted in terms

of control of the final common path. We have here a concrete situation in which to interpret coöperation and opposition; *i.e.*, facilitation and inhibition of nerve impulses. The point is that arcs from all parts of the nervous system use the same muscles. A particular muscle fiber may respond to a simple sensory stimulus, or to a most complicated conscious and voluntary act; but, it can never be reached except through the "final common path," the motor neurone leading to that fiber.

The afferent arc. — Like the final common path, the afferent neurone also furnishes a common channel through which nerve impulses may discharge into countless other channels. The nerve impulse from a prick of a needle on the tip of the finger may set up only the simple reflex which results in the withdrawal of that part of the finger; but it may radiate and discharge into practically every muscle of the body if the pain is intense. Yet the impulse was conveyed over a single afferent arc to the spinal cord.

The central neurones. — The whole mechanism for the switching, the diffusion, the complication, and the concentration of nerve impulses, therefore, lies in the system of central neurones. These constitute the bulk of the central nervous system. In the simplest case, a single central neurone lies between the afferent and efferent neurones in the spinal cord. In the most complex case, the nerve impulse may have to thread its way in divergent paths through millions of neurones in the spinal cord, the basal ganglia, and the cerebral hemispheres. No nerve impulse is without effect. A stimulated neu-

rone discharges its impulse into an effector or into another neurone which in time passes it on. The main interest to psychology here lies in the fact that, between the afferent arc and the final common path lies the bulk of the central nervous system so organized as to furnish an adequate organ of consciousness and mechanism for countless automatic coördinations.

The laws of association in terms of resistance. — Since the nerve impulse follows the line of least resistance, the path of any nerve impulse may be shifted from circuit to circuit by varying the resistance at strategic points. The means for such variation of the resistance we have found in the mechanism of the synapse, the point at which connections are made.

The resistance of a given path is lessened by use; other things being equal, the more frequently a nerve impulse has followed a particular circuit the less resistance it will offer and the more readily it will be followed thereafter: this is the law of repetition or frequency. It is the law of habit and instinct. Other things being equal, the stimulus of a given character having once established a circuit, this path offers less resistance and will be followed thereafter: this is the law of primacy. Other things being equal, the circuit last followed leaves the path freest from resistance. This is the law of recency. Other things being equal, the circuit taken by the strongest impulse will offer the least resistance: this is the law of intensity. Other things being equal, the course followed in an agreeable experience offers less resistance: this is one of the aspects of the law of emotional congruity.

Thus, our laws of association are conceived, stated, and explained in terms of purely physical principles governing the transmission of nerve impulses through the mechanism of varying the resistance at the synapses.[1]

Central complication of reflexes. — Combination of reflexes may be simultaneous or successive, allied or antagonistic. The exciting of the wiping reflex in the frog from adjacent areas simultaneously would be an example of simultaneous allied reflexes: they coöperate effectively to the extent that they have a common task. Walking is an example of successive reflexes: each step excites a complex system of receptors which in turn discharge into the appropriate effector for the next step. When two reflexes in command of the same effector are opposed, as when one reflex moves a limb forward and the other backward, they are said to be antagonistic. Here the principle of interference plays an important rôle. It is the function of some arcs to inhibit action. The muscular system is normally under constant tension: with every energizing for a movement is associated an inhibition or release of antagonistic movements. There must be a balancing of forces.

Considering the profuse supply of afferent arcs from all parts of the body, the presence of common paths to every muscle, and the existence of millions and millions of central neurones organized for synaptic functional relation in the forming of central paths, we find in this principle of the complex neural arc a mechanism

[1] Sherrington points out four general features that tend to determine the sequence or dominance in competing reflexes; namely, spinal induction, relative intensity of the stimulus, relative fatigue, and the functional species of the reflex. These are taken for granted in the above statement of the laws of association and are covered by the proviso "other things being equal."

adequate to form a neural basis for all that man can know, feel, or do. Modern psychology maintains that there is a physical correlate for every mental process — not only in sensation and action, but equally in the higher, more complicated and more abstract processes, such as memory, imagination, thought, emotion, and sentiment. And the fundamental principle of this neural organization is the law of association, as operating in the central neurones. From the physiological point of view this may be regarded as an extension of the principle of the reflex arc.

The human nervous system is a microcosm (a small organism) as the stellar heavens are a macrocosm (a large organism). Each of the thousands of millions of neurones in the nervous system of man is an organism complete in itself with the power of generating, storing, and transmitting energy. Each neurone is made up of millions of molecules, and each molecule, the physicist tells us, is as complex as the modern man-of-war. The spaces between the atoms of molecules have been likened to the distances between the heavenly bodies in our solar system. In this microcosm, as in the stellar macrocosm, we believe that not an atom moves except in accordance with natural law.

Organization *vs*. mechanization. — We have attempted to convey, as far as possible in high lights, a conception of the nervous system as a living organism built and working at every stage on natural principles. Every presentation of this sort is misleading in that it is sketchy and assertive and does not convey any adequate conception of the infinite intricacy of organization and

richness of relationships, and is couched in our very superficial and fragmentary concepts of what natural processes really are. In short, it offers too simple an explanation. We should, therefore, perhaps safely urge that the conception presented be regarded as figurative and skeletal rather than exact and detailed. Among the convictions that the psychologist gets more and more deeply impressed as he studies any mental process are the unfathomableness and profundity of the organization of nature and the limited means of interpretation and description now at our command.[1]

[1] "Often our powers of prevision are balked. It is true that where we are dealing with repetitive routine, little more is required than a skilled application of our powers of calculation. But in the evolution which supersedes routine we have again and again to confess that we cannot foretell how the world-story will work out in the future. This, however, I contend is not because the inherent development of the story will be lacking in logical coherence; it is because our imperfect insight and reason fail to grasp the determining factors within the deeper logic of the universe." (Lloyd Morgan)

CHAPTER XIV

MIND AND BODY

In the present chapter we shall merely touch briefly upon four general aspects of the study of mental life: the general traits of consciousness, the nature of the subconscious, behavior, and the psychophysical theory.

Consciousness

Consciousness is the characteristically mental aspect of life. Psychologists frequently use the terms "consciousness" and "experience" interchangeably. Without attempting to define the obvious and immediate, we may say that by consciousness, or experience, we ordinarily mean some form of awareness; as, for example, in seeing or hearing, remembering or imagining, thinking or feeling. Indeed, consciousness as a continuous process may be regarded as the sum total of such mental processes functionally integrated from moment to moment.[1]

"**Four characters in consciousness.**" — Under this head James points out four fundamental traits of consciousness in general, which anyone can readily observe; namely, (1) every mental state tends to be a part

[1] "Consciousness is the ability of an organism to decide upon a course of action at this present time, such as will secure that organism's welfare at some future time." This definition, given to the author informally by Ritter, is a good example of the functional definition of consciousness now in vogue in biology.

of a personal consciousness; (2) within each personal consciousness the states are always changing; (3) each personal consciousness is sensibly continuous; (4) consciousness is always interested more in one part of its object than another, and welcomes, rejects, or chooses all the while it thinks.

EXERCISE. — *Think intently for one minute, repeatedly, on the problem, "The effect on human life of the introduction of the automobile," and write out, from your introspections, a series of illustrations to substantiate the claim that your consciousness in this act was (1) personal, (2) always changing, (3) sensibly continuous, and (4) selective. Use only original observations from this act of introspection.*

(1) *Personal.* — If you should compare notes with another student, you would probably be impressed with the fact that, while you were aware of a number of the same facts, each of the items in your stream of consciousness had some personal relation to yourself. No matter how similar, they could not be shared or duplicated. Each thought was exclusively your own, even though you may have accepted the cue from some one else. For each time that you repeated the introspection, you became more and more convinced that the illustrations brought out had some relation to your own personal life and that the picture in your mind was characteristic of yourself — a projection of your personal experience, interests, range of information, logical power, ambitions, possessions, ideals, capacities, and aptitudes. You shared with no one an exact image of any automobile, process of reasoning, or feeling of the value that you attributed to the coming in of the automobile. You ex-

perienced a personal feeling of self-exertion, warmth, and exclusiveness, and a feeling of personal limitations, or a power of grasp of the situation which was peculiarly your own. You felt yourself single-handed in a personal encounter with a problem.

(2) *Changing.* — Not only did the entire mass of your "stream of thought" move on for every fraction of a second under observation, but there was a constant flux in internal arrangement and a constant "turnover," new elements continually rushing in and present elements rapidly being sloughed off. For each minute that you repeated the same task, your experience was radically different; you could not, in any sense, repeat the thought. Even concrete facts which you used as a basis of argument appeared to you each time in different setting and different meaning. No state of consciousness recurred in successive trials without profound change. As a person, you felt yourself at the mercy of this "fleeting show" of the mass of flashes of consciousness. You realized that there was no possible moment of repose in a fixed state of consciousness. You caught yourself irresistibly acting. You beheld, during these moments of observation, a good example of the "flow" of consciousness.

(3) *Continuous.* — Yet, in all this array of fleeting, personal encounters, you had a feeling of continuity. Each image or idea followed in turn upon the preceding in accordance with the laws of association. You thought of yourself as a permanent subject of these experiences, although you were aware of gaps, lapses, and moments of helplessness. Yet, these very awarenesses of inter-

ruption and incoherence stressed your feeling that the observed fragments belonged together and were a part of your continuous consciousness. Indeed, you observed no "parts"; at every stage you observed aspects of the functioning of a continuous organism. With progressive training in introspection, you will acquire greater power to observe relationships in consciousness and realize that in this feeling of the continuity of the stream of thought lies the foundation for your awareness of yourself as a personality.

(4) *Selective.* — In the above introspection you were much impressed with the responsibility for selecting point of view, values, examples, conclusions. Numerous wide vistas of possibilities lay open before you, and the initiative that you exercised consisted largely in the selection of your course from those which spontaneously came into the foreground in accordance with the laws of association. Your entire organism was selective. Your attention focused on the outcome of an exceedingly small portion of the consciousness before you at a given moment. The thinking you did under these conditions was limited by the limit of your natural capacities, senses, training, habits, and interests. In other words, you found yourself in various ways determining the turn of events in consciousness. When you analyze this self-activity, you will find that it can best be expressed in the idea that your consciousness itself — what you are — selected the objects of interest, attention, and significance on the ground of its own character.

Focal and marginal consciousness. — In the study of discrete processes, such as sensations, images, associa-

tions, and ideas, there is danger of gaining the conception that consciousness is made up of isolated units of this kind, in a sort of molecular structure. There has been a tendency in all ages toward a mechanistic interpretation of consciousness in terms of so-called elements. To offset this, we must think of consciousness as an organism, with all its parts functionally interrelated, blending, fusing, and working together. Perhaps we can illustrate in the case of a good picture of a landscape: here in the foreground is a herdsman, a flock of sheep of which a few stand out in clear features, a tree, a few shrubs; in the distance lie stretches of timber, meadows, a field, a river, and sky, dotted here and there with suggestions of houses, herds, birds, and clouds. That is the landscape, the picture we can grasp in a moment of consciousness; and this is typical of the content of consciousness at all times: there are one or more significant things in the clear foreground which catch our attention and, receding out from these, lie related objects, events, and situations, fading off indefinitely into the remote distance. As attention moves from one object to another in the foreground, the massive background changes less and thus furnishes a setting, a bond of continuity in the experience of successive objects in the foreground. The objects which gain attention are few in comparison with the masses of related objects in the setting; yet the remote objects, even though faintly suggested in their part of the picture as a whole, give tone to the foreground.[1]

[1] To apply this illustration, think for just a moment of your home. Perhaps in this picture the house was in the foreground and the camera of your consciousness, as it were, snapped in rapid succession a tree, a man, a shrub, and so

It has been customary to show the relation of the focus to the margin by a series of concentric circles in which the innermost, small circle represents focal consciousness, and succeeding circles outward represent the more and more receding background of consciousness. The nature of this extreme, marginal consciousness we shall consider in a moment. Let us here merely note that only an infinitesimally small part of the stream of consciousness is clearly focal, and that the vast mass of mental processes surge in the marginal background, receding gradually beyond the dim horizon. Herein lies the explanation of the "sensible continuity" of consciousness which you observed in the exercise. The focus of consciousness flits from object to object in the foreground, but the sensible bond lies largely in the array of related processes in the more or less remote background.

The Subconscious

Difficulties encountered. — One of the most debatable issues in psychology pertains to the nature of this receding, marginal consciousness and what lies beyond, usually spoken of as the subconscious or unconscious. The idea of the subconscious has been a term to conjure with on the part of all kinds of mystery mongers in alleged psychology. For this there are several reasons. It is a field which has not yet been organized by systematic experiments in the laboratory, and, therefore, its full significance has not been grasped and it has not been adequately formulated in scientific psychology.

on, and each of these carried in the background certain common elements characteristic of the home environment and in the same way tied up with your early life.

It is not readily approached through direct introspection. It manifests itself most conspicuously in abnormal and pathological cases. It is by its very nature mysterious in that it often seems to function as a consciousness outside of the personal consciousness. In legitimate psychology it has furnished a most satisfactory explanation of the strange, the weird, and the apparently supernormal, as in hypnosis, alternating personality, and all forms of automatisms and is, therefore, resorted to by the ignorant and uncritical as a cover for anything which is mysterious to them. This, in turn, has made it an easy victim for identification with all sorts of uncritical, semi-religious, pseudo-philosophical and quasi-scientific theories as to its ultimate nature.

Theories of the subconscious. — Among the aspects of theories presented critically by psychologists, but which seem to be passing, we may note the following: (1) According to the theory of "unconscious cerebration" all that is not conscious is denied the appearance of mentality and the facts are interpreted entirely in terms of neural activity. Münsterberg's voluminous writings on the subconscious from this point of view are summed up in the declaration, "There is no subconscious." All that is below the strictly conscious is regarded as purely physiological activity. The term consciousness is, however, used in a broad sense, *e.g.*, so as to include dream consciousness and many other phenomena usually classified as subconscious. (2) The so-called "storehouse" theory regards the subconscious as a vast mental storehouse in which each mental experience, such as sensations, memories, and ideas, are stored away as mental

states which may be withdrawn from storage under certain circumstances. (3) The " subliminal self " theory injects a metaphysical doctrine in regard to the reality, dignity, and function of this so-called subliminal self which throws the waking consciousness into a comparatively subordinate position. It regards this subliminal self as the source and foundation of the true self and carries a number of assumptions in regard to immortality and other transcendent characteristics of this self.

Present use of the term. — There is great diversity of opinion among psychologists on this subject, but, throughout this book, we are proceeding on the theory that the subconscious represents those processes which are outside of the focus of our attention to processes as related to the waking self. We regard the subconscious as an extension of consciousness, the distinction between conscious and subconscious being merely that we call those mental processes " conscious " which we are aware of experiencing at the time of the experience in the waking state, and all other mental phenomena subconscious. As in the illustration of the landscape above, there is no sharp line between the focal region in which distinct features or objects are observed in turn and the vast region beyond this in which features are massed.

The term "subconscious" seems to involve a contradiction. There is a tendency to identify conscious and mental; the subconscious would, therefore, imply something under the mental, not mental. This difficulty, however, rests mainly upon a poverty in words. According to our view, the subconscious is mental and it is of the same kind as the conscious, the mental being di-

vided into the conscious and the subconscious. It is merely remote in a part of the waking system of self-awareness. The subconscious may be clear, discriminating, and organized around a remote personal nucleus, just as the conscious is. In the analogy of the painting, one's observation may center about any feature, however trifling, to such an extent as to result in utter obliviousness to both self and painting as such. Our theory denies the assumption that ideas and impressions are stored, as implied in one group of theories; it disavows any metaphysical assumption in regard to the subliminal as a form of ultimate reality; it takes a broader view than the theory which regards the subconscious as a split-off fragment; it recognizes the adequacy of the physiological account of all neural processes underlying mentality; it recognizes the vastness of the subconscious element associated with our ordinary conscious life; it draws no sharp lines between the conscious and the subconscious; and does not attempt to determine the limit of mentality.

Some concept like this is indispensable to the full account of any mental process as it represents the bulk of our whole stream of mental life. From this point of view we may represent in the triangle of Fig. 20 a cross section of ordinary processes at a given moment. At the apex of this triangle, a very small section, shaded black, designates the corresponding conscious field; and below that, the subconscious, gradually fading out into the unconscious region of neural processes not associated with mentality. The figure should impress two facts: first, the correlation of the physical and mental down to

some yet undetermined limit below the level of waking, self-relating consciousness; and second, the relatively small scope of the focal consciousness as compared with the subconscious and the unconscious.

Provided we bear in mind that all three levels are a part of the same living organism, and that whatever occurs at any level modifies the whole cross section, it would be quite possible, in a figure of this kind, to suggest an infinite number of courses in the process from impression through elaboration to expression in mental and neural activity, showing that a process may be initiated at the conscious, subconscious, or purely neural level, and may be both elaborated and expressed at any of these levels.

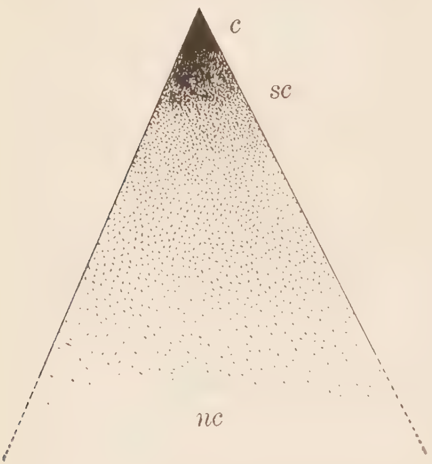


Fig. 20.

Behavior

There are two fundamental approaches to the study of mental life. One is introspection, of which we have abundant examples in the preceding chapters; the other is behaviorism of which we have also had a number of examples. In the former, we approach the study from

the point of view of conscious experience as, for example, in the study of color effects, or in the preceding observations on the characteristics of consciousness. In the latter, we proceed entirely on the basis of control and registering of physical stimuli and movements. Both introspection and behaviorism may be conducted in various degrees of exactness and control ranging from loose, random observation to rigidly controlled conditions of experiment. Most of the laboratory work done in psychology combines the two methods.

In the extreme attitude of behaviorism we entirely disregard the testimony of consciousness and simply record objective stimuli and the reactions thereto. This method is particularly advantageous in the study of lower organisms; as, for example, in observing reactions to light, temperature, contact, and the various chemical stimuli. The method may, however, be extended into the study of the higher mental processes both in man and animals, as, for example, in measuring ability to sense, discriminate, remember, learn, and even to think or act under the influence of feeling and emotion. But behaviorism ordinarily justifies itself by translating such observed facts into terms of experience. All experiment and measurement in psychology is based upon the assumption that the psychophysical organism is a unit. Man as a human being is therefore a creature that lives in accordance with natural law. Nothing happens without a cause and every cause has its effect; and in most situations in life it is possible to set conditions so that the effect will be expressed in bodily movement of some kind.

The behavioristic method has the advantage of not stopping to differentiate what is mental and what is physical. Thus, in studying the learning process it does not consider what elements of the process are conscious, subconscious, or unconscious. It simply sets conditions and observes results; and in this manner it is quite possible to work out in finest detail the laws of learning, of forgetting, of concentration, of distraction, etc. In its pure form, the behavioristic method is physiological; and the science which results from it is the science of behavior, which may or not be interpreted in terms of experience or consciousness.

An example of the most natural use of this method may be seen in the study of behavior in the infant. During the early period of infancy we cannot get any direct report from the infant about its experience. Our observations must all be expressed in terms of behavior as described by stimulus and response. But the dominant attitude in our technical laboratory experiments is essentially behavioristic. The same is true of mental tests.

Experiment in animal psychology of necessity takes a behavioristic character. In the new behavioristic movement, experiments on animals are likely to be made for the purpose of discovering general biological principles with particular reference to man. A rather extreme and quaint illustration of this type is given in the following footnote on "The Psychology of Monotony."[1]

[1] **A behavioristic experiment: "The Psychology of Monotony."** – Professor Boldyreff in Russia has just published an experiment, making use of what is known as the salivary reflex. A dog is provided with a little capsule which collects the saliva as it is secreted by the salivary gland upon being fed.

Psychologists who are not behaviorists use the term "behavior" legitimately in a broader sense than that

Experiment 1. — The dog was given a morsel of bread and at regular intervals this was repeated, the dog apparently relishing the food; and it was observed that for each feeding, four minutes apart, the secretion of saliva decreased both in quantity and quality.

Experiment 2. — The dog was fed under the same conditions something injurious and irritable, and it was observed that for each successive feeding the flow of saliva tended to increase both in quantity and quality.

Both experiments were repeated after a lapse of several days of time, and in each case it was found that the original condition had been restored. Hence we have three laws: (1) The repetition of a pleasant stimulus progressively loses in effectiveness of the responsiveness of the organism. (2) The repetition of an unpleasant stimulus increases the responsiveness of the organism. (3) Prolonged rest from either of the above results in normal responsiveness of the organism.

On these facts he has formulated the principle of ***habituation.*** After discussing the physiological significance of this, he suggests certain psychological deductions and applications of the principle in the following quaint language of a foreigner writing English. The gist of these applications may be summarized as follows: (1) Sameness of food that we take daily injures digestion and therefore nutrition. (2) Uniformity of certain conditions in the time of eating is in the same manner unwholesome. This injurious effect of monotony is overlooked by modern dietitians, as change is necessary for the normal appetite. (3) Migration to remote lands with quite a difference in general and quite different products of food in particular enforces digestion and therefore favors nutrition. It consequently enforces the vitality of migrants. The advantage of traveling has its foundation chiefly in the alteration of diet and fashion of living. (4) First impressions are always strongest: first love, first success in work or play, first hunting, and the like, give to men the most joy and happiness; therefore childhood, as the time most rich with first impressions, affords us much joyfulness. (5) A long interruption restores the vigor of pleasant impressions and weakens that of unpleasant ones. (6) Monotony of life lessens the interest of it and produces the feeling of boredom. Therefore the monotony of life in institutions is unwholesome. (7) The curiosity of women depends upon the great monotony of their life in comparison with that of men. Curiosity of savages rests upon the same principle. (8) The feeling of curiosity — the love of knowledge — is the most important agent of intellectual progress for an individual and for mankind. (9) Human response may be divided into the useful (pleasant) and the injurious (unpleasant). During the life of every man, both are inevitably often repeated. The repetition of injurious reflexes strengthens their action and therefore in the course of life they become more and more injurious, excessive, and irritable. The frequent repetition of useful reflexes during life weakens more and more and therefore inevitably causes deterioration, both spiritual and bodily. This is one of the chief reasons for aging. (10) The tendency of women to adorn themselves and follow fashions is necessary for the lessening of the uniformity of life. (11) The sum of pleasant sensations diminishes in the course of life. (12) Life in the tropics lessens the power of the human spirit because in all its richness it is more uniform than where there is

indicated above. McDougall, restricting behavior to the action or actions of some living thing, points out the following marks of behavior from a psychological point of view: (1) certain spontaneity of movement; (2) persistence of activity independently of the continuance of the impression which may have initiated it; (3) variation of direction of persistent movements; (4) coming to an end of the animal's movements as soon as they have brought about a particular kind of change in its situation; (5) preparation for the new situation toward the production of which the action contributes; (6) some degree of improvement in the effectiveness of behavior, when it is repeated by the animal under similar circumstances; and (7) [purposive action is] a total reaction of the organism.

Psychophysical Theory

As to the relation of mind and body, we are confronted with three problems: (1) What is the ultimate nature of mind? (2) What theoretical assumption shall we make about the relation of mind and matter? (3) What are the observable facts about the relation of one to the other? [1]

a change of seasons. (13) Happiness to mankind will come more through the progress of science and culture than through the simplification of life. (14) There is also spiritual satiety. The taking of spiritual nourishment follows the same principle as the taking of physical nourishment. (15) "What for is sleep necessary?" It is necessary in order to provide interruption of the pleasant and recovery from the unpleasant. (16) Increasing of the force of unpleasant impressions is the cause of irascibility of old people. (17) Irascibility of a bedridden, sick person, a prisoner, or a chained dog is connected with the monotony of the conditions of their life. (18) The same reason explains the mutual irascibility of the inmates of small cabins. (19) This irritation can be so strengthened as to result in madness. (20) Repeated pains became in time more and more difficult to bear and can even kill a man. The same is true of spiritual pains.

[1] "The sharp distinction between mind and body is a very ancient and spon-

Nature of mind. — What is mind? This is the oldest and most persistent question in philosophy and psychology, even in the reflections of untutored and primitive man. On the answer given to that question rest large bodies of myths, cults, philosophies, theologies, religions, and systems of science as well as peace of mind in the attitude of so-called common sense. The history of thought and civilization reveals thousands of theories of origins of spirit, kinds of spirits, and destinations of spirits, with the corresponding regulation of practical life. On the theory of mind as the ultimate reality, philosophers have built systems of interpretation of the world, and founded ethical standards of life. On the theory of mind as a functional phase of the psychophysical organism, scientists are divided into camps, schools, or attitudes which hold such radically different views of the origin and function of mind as to color vividly their account of observed facts in all the biological and regulative sciences, even in the practice of medicine.

The question belongs to the realm of philosophy which is concerned with the ultimate nature of all things, such as mind, matter, knowledge, force, casualty, time, and space. The great thinker in each and every science inevitably comes to the philosophical approach of this issue in his mature thought. Fortunately, an answer

taneous, uncritical, savage prepossession What we think of as mind is so intimately concerned with what we call body that we are coming to realize that the one cannot be understood without the other. Every thought reverberates through the body; and, on the other hand, alterations in our physical condition affect our whole attitude of mind. There are hidden impulses and desires and secret longings of which we can only with the greatest difficulty take account. They influence our conscious thought in the most bewildering fashion." (Robinson, *Mind in the Making.*)

to this first question is not essential to the science of psychology, tantalizing though the craving for a solution may be.

The situation is exactly the same in mental science as in material science. No physicist knows what matter is; yet the question as to the nature of matter is as persistent and fundamental as the question about the nature of mind. In scientific psychology we pass over this question in the same way as, for example, in electricity. No electrician knows, in the final analysis, what electricity is, yet he knows many of its laws, its relation to light and heat, how to produce it, how to use it, how to describe it, and how to control it. Exactly so it is in the case of mental life, except that the phenomena are vastly more complex, and in many respects less tangible. Philosophy, to-day, presents plausible answers to this question; but for a scientific psychology, there is nothing gained by a mere naming or statement of such answers, because to understand anything philosophically, it is first necessary to think yourself into the situation through persistent training and discipline in philosophical thinking.

Relation of mind and body. — The second question is also primarily a philosophical one, though partly also scientific; but here the practical situation is different. In order to make any coherent and systematic description and explanation of mental life from a scientific point of view, it is necessary to proceed upon the assumption of some type of answer to this question. A theory of psychophysical relation is an essential prerequisite of scientific psychology. The observed facts may be re-

ported fairly faithfully from the point of view of different theories; but any coherent account that is made will at once reveal an underlying theory.

Current theories may be divided into two classes, the dualistic and the monistic. Dualism attributes real existence to both matter and mind, and has generally taken one of two forms — interactionism or parallelism. According to interactionism, body and mind stand in causal relations, so that each may act upon the other; according to parallelism, mind cannot act upon body or body upon mind, but the two kinds of action run parallel. Monism attributes reality to only one object of experience. Idealism maintains that this one reality is mind; materialism, that it is matter; and the double aspect theory that mind and matter are merely two aspects of the one more fundamental reality.

You will observe that the double aspect theory best fits our view in this book. It denies the causal relation implied in the interaction theories, and recognizes the observed facts of parallelism, but denies the duality of mind and body usually implied therein, and asserts that the mental and neural are two aspects of the same life process. Until recently, those who have held this view have classified themselves as parallelists; as, for example, Titchener, whose view is that "consciousness and neural activity are simply two aspects of the same experience." This double aspect theory has been most recently stated by Warren:

"The Double-Aspect interpretation differs from both Interactionism and Parallelism in assuming that conscious and neural phenomena constitute *one single series*

of events, and that their different appearance is merely due to different ways of observing them. When they 'happen to me' they appear as conscious experiences; when I observe them indirectly, through perceiving the behavior of other beings by means of my senses, they appear in the form of motion, chemical change, and the like.

"According to this hypothesis, consciousness 'belongs to' the activity of neurones as truly as the intensity or form of neural impulses belongs to this same activity. Just as in physics, when we discuss the properties of *masses* we find correlated phenomena, such as *surface* relations, which may or may not be studied but belong to the same group of phenomena, so in biology when we examine the *properties of nerve substance* we observe certain correlated phenomena called *conscious experiences*. They form part of the 'total description' of nerve activity. In physics the same event or group of events may be studied through several different manifestations: we observe increase in heat through rise of mercury in a bulb or through the fusing of some metal. Neural events, according to the Double-Aspect hypothesis, are likewise observable either as behavior or as 'our own' experiences.

"The Double-Aspect hypothesis is adopted here because it does not clash with observed facts and because it seems to provide the best working tool for psychological investigation. It enables us to bring the results of objective and subjective observation into coöperation — using our physiological and behavior material to bridge the gaps in conscious experience, and using the results of self-observation to supply the missing data of brain activity." (*Human Psychology*, pp. 415–416)

Observable relationship. — The answer to our third question runs throughout the treatment of the entire subject of psychology. In sensory experience, we ob-

served how sensation and perception were in every way correlated with corresponding sense organs and central neural activity. This principle, as applied to the higher mental processes, came to the foreground in our treatment of association and neural theory. The position taken there might be restated for every mental process that is discussed; but it will be readily seen that in the treatment of memory, imagination, feeling, emotion, impulse, and action, no new principle is introduced. The psychophysical relation recognized in the double aspect of association becomes an all-pervading principle of interpretation throughout all the higher mental processes.

CHAPTER XV

INSTINCT

"TAKE the house cat and follow her through the life of a single day, observing her actions. She washes her face and makes her toilet in the morning by instinct. She has her peculiar instinctive way of catching the mouse for breakfast. She whets her appetite by holding back her meal possibly for an hour, in the meantime playing most cruelly with the pitiful mouse, letting it run and catching it again, and doing this over and over. If she has children she attends to their training in the details of cat etiquette and custom with the utmost care, all by instinct; and the kittens instinctively respond to her attentions. She conducts herself during the day with remarkable cleanliness of life, making arrangements which civilized man follows with admiration. She shows just the right abhorrence of water for a creature that is not able to swim. She knows just what enemies to fly from and when to turn and fight, using with inborn dexterity her formidable claws. She prefers nocturnal excursions and sociabilities, having eyes which make it safe to be venturesome in the dark. She has certain vocal expressions of her emotions which man in vain attempts to eradicate with all the agencies of domestication. She has special arts to attract her mate, who in turn is able to charm her with his songs which charm nobody else." (J. M. Baldwin)

"Instinct is the faculty of acting in such a way as to produce certain ends, without foresight of the ends and without previous education in the performance." (James)

EXERCISE. — *(1) On the model of the above illustration and tentative definition, describe as fully as you can the instinctive behavior of an infant, or of some animal with which you are thoroughly familiar.*

(2) In reading this chapter, gather data that may be used as a basis for the comprehensive definition of instinct called for at the end of this chapter.

There is at the present time no general agreement as to the nature of instinct. The conflict of theories is bewildering, involving a mass of psychological, neurological, and biological controversies. Among crucial phases on which authors differ are the following: What is the relation between instinct and intelligence? What is the relation between instinct and reflexes? Are there any "instincts"? Shall instincts be regarded as purely physical processes? Is instinct limited to action? Is instinct associated with the higher brain processes? In what respect does the theory of instinct replace the doctrine of innate ideas? What philosophy of mind and body shall we accept? What attitude shall be taken in the current biological controversy between vitalism and mechanism?

It is not essential, not even desirable, to secure a final and complete concept of any subject like this. What we want is insight into the problem and a realization of its significance. To this end we may, perhaps, think ourselves into the situation by following critically the direct presentation of a theory which is consistent with the general point of view that runs through this book. This theory may be stated progressively in terms of the leading characteristics of instinctive behavior.

Organized heritage. — Instinct is an inherited mode of behavior. It represents what survives of the progres-

sively organized habits of the species as a whole. Without raising the question as to the method of inheriting acquired traits, we may assume that the common and persistent elements in the habits of our millions of progenitors are transmitted in the progressive organization of the nervous architecture of the species through evolution from the humblest living organism to the highest — man. Therefore, instinctive behavior is determined by the organized reflex arcs which remain intact on the ground that they represent the well-worn racial paths.

Reflex. — From the neural point of view instincts are reflexes, usually very complex, ranging from the simple reflexes up to sublimations of reflexes in the most intricate higher brain patterns. The simple reflex stands to instinct in about the same relation as pure sensation to perception. Sensation is the elemental form of cognition. The reflex is the elemental form of the sensori-motor and associative processes as a whole.

Mental. — Instinct is a mental concept which is employed to denote the mental aspect of complex reflexes to the extent that mentality may be recognized in their operation. Neurologists tend to ignore this term and render their account purely in terms of reflexes. In this they are undoubtedly right in so far as they deal with the physical side only. All organization of neural processes may be conceived in terms of the reflex arc as a unit — even in the neural correlate of memory, sentiment, and reason. But the acceptance of this does not prevent us from regarding memory, sentiment, and reason as mental processes and using them in our account of experience, which may be purely in mental terms. We

are just as certain that physical correlates exist for memory as for instinct.

This is a somewhat arbitrary way of settling the controversy about the relation of instinct to reflexes, but it is the logical outcome of the best tendencies in psychology at the present time. That is to say, we regard one as the physical, the other as the mental aspect of the same processes, in the sense that they are parallel. Within a certain limit, each one-sided description assumes the other. In this manner we shall use instinct to denote a mental fact of which we recognize a specific physical correlate, the reflex, just as we used memory and imagination to denote mental processes of which we recognized correlative neural aspects.

Not conscious. — The pure instinct is not conscious either as to the end served or as to the means of reaching it before the instinct has been expressed. Like the simple reflex, pure instinct rarely occurs, but the concept is true and convenient in the structural interpretation of complex instincts. The pure instinct has essentially the same characteristics as the simple reflex: it is quick, specific, purposive, organized, and adequate. "It is not modified by considerations." To what extent instinct processes, which are not conscious, may be interpreted as subconscious is a matter of theory at the present time. We do not hesitate to employ a terminology which implies the existence of subconscious mentality; but at the present stage it is better not to dogmatize about the nature or the extent of such subconscious experience.

Accompanied by consciousness. — The pure instinct,

may, however, be accompanied by consciousness. In response to the pin prick the unconscious reflex takes place before there is time for the consciousness of pain, yet the same nerve impulse that touched off the reflex may also radiate to the brain so that we may be clearly conscious of pain and modify the diffusion of the reflex in its later stage as a result of the pain. In the case of massive reflexes, such as fear, surprise, or flight, involving the whole organism, there results a mass consciousness or feeling of undifferentiated impressions, their meanings, their expressions, and their conflicts. This we shall find later is the common source of emotion and is often spoken of as the instinct feeling or the instinct impulse. In other words, although the purely instinctive stage is entirely unconscious, the common instinctive acts run gradually into each and every one of the conscious forms of knowing, feeling, and action.

Blends. — Instinctive processes are normally blended into habituated conscious and voluntary processes. The pure instinct being essentially a theoretical matter, our main interest lies in the instinctive blends or fusions in which instinct may be more or less a dominant factor. We recognize for instinct, then, the same flexibility of interpretation as we have recognized for the cognitive processes. For example, your eyes are cast upon the setting sun and you exclaim, " What a beautiful sunset ! " Your mental processes at the moment are sensations, perceptions, memories, images, thoughts, emotions, and responses — let us add, instinctive joy. No mental process is purely of one mental category. Even in the simplest situation the mental organism tends to respond as

a whole. This fact is fundamental for our conception of instinct or, as we may appropriately say, instinctive behavior.

In all mental life. — Instinct is present in all mental life. It is not restricted to action as is commonly held nor is it restricted to the lower animal life. It enters into all knowing, feeling, and action of human as well as animal beings. You and I have instincts to do everything that we can do; to act in defense, to grasp in every sense of the word, to imagine, to feel, to think. The instinctive processes may be traced as a factor in all the degrees of intelligence, feeling and will, ranging from those processes in which it is dominant and approaches purity, up to those complex processes in which we could recognize its presence only theoretically. That is to say, in actual experience instincts are not isolated unit acts, but the instinctive character is present to some extent as an ingredient in all mental life.[1]

Instinctive, not "instincts." — We must think of instinctive processes as opposed to instincts. The noun in the plural implies the existence of acts intact; whereas the adjective recognizes the presence of instinctive traits in blends or complexes with other processes. The noun in the singular is used correctly in the same sense as the adjective. This becomes a matter of importance when the attempt is made to explain anything in terms of instinct.

[1] "Suppose a bird were to become interested in zoölogical investigations; he might well regard man as the richest of all creatures in instinct. Man shares with the bird the instinct to live in wedlock; like the fox he educates his children; he has the beaver's impulse to build houses, the bee's custom of founding states and sending forth colonies; while he has in common with the ant a pleasure in war, in slave-making, and in domesticating useful animals." (Wundt)

After the chick has pecked the first time, after the bird has launched on its first flight, after the infant has nursed for the first time, each has experience which, from that point on, progressively modifies the instinctive behavior by associating it with their experience. The instinctive tendencies to peck, to fly, and to suck persist not only in the specific acts in which they first occurred, but also in countless other acts, as we shall see later. The sucking instinct, for example, persists not only in all eating, but in the kiss, the smile; in the meaning of perception, imagination, memory; or in the thought of good things to eat, in the puckering of the lip, in the thrill at the beautiful sunset, in the realistic mental representation of anything regarded as "good for me."

Purposive. — Instinctive behavior is purposive. It consists of the organized responses which have served the purpose of the organism in the species. If the same acts were done as a result of will we should call them purposeful. No matter how far the instinctive tendencies have been spread and attenuated in the blend of adapted responses, the strain of what remains is always purposive. This does not deny the fact that many instincts fail in their purpose as, for example, the paralyzing situation in fear. This we explain by the fact that the same purpose may be accomplished by many and different means. For example, we may avoid danger by retreating or by driving danger away; but the movements involved in the two cases are opposite; both are instinctive and each involves the principle of the reflex which may be regarded as rudimen-

tary. The success of the instinctive responses should, therefore, be judged in terms of the conflict.

Correlated with organs. — Every organ, every effector in the animal organism, has its governing instinct. This is the condition of its emergence and survival. Animals that have claws scratch, horns hook, glands secrete the gland product, wings fly, eyes see, nostrils smell, developed forebrain think, feel, and will. This instinctive behavior is not limited to muscular action but includes sensory, cognitive, and affective aspects as well. The term organ is used here not only in the limited sense of a limb or a sense organ, but also in the broader sense of organization or integration of the nervous system in part or as a whole.

Organic memory. — Instinct is the exercise of racial organic memory. To the extent that it is not conscious it can not consist of awareness of specific objects or events. It takes instead a simpler form of immediate expression in behavior. Thus, instinctive acts are memories at work — expressed. A very large part of life consists of such organic memories, pure and simple; but, from our point of view, organic memory enters to some extent into every complex form of mental life. We can understand feeling and knowing, even in their most complex and refined forms, only as we recognize in them the wonderful organizations of countless fragments of organic memory, each a faithful reporter of the past, struggling for expression in a melée of conflicts.

Organic memory takes the form of purposive responses to stimuli, not only in the usual sense of a com-

plete stimulus response, but in a much more significant way through the countless partial responses that enter into feeling and knowing and action. We do not recall the wars, the struggles for existence, the roamings over the wild, the primitive independence of tools, the fears of animals; but we have deeply ingrained in our nature the tendency to respond in the way in which individuals of the race have responded. In anger, *e.g.*, we display most of the activity involved in preparation for hand to hand conflict.

Reversion to type.—It follows from the preceding that instinctive acts always exhibit a tendency toward reversion to type. To fight, to love, to hate, to solve a problem — to engage in any complex act instinctively — means that there is a tendency to strip the act of deliberation, variation, or consideration and perform it in the way it was performed in earlier racial life or earlier species.

Modifiable. — Betting on instinct would be dull betting, it has been said, because there is no chance about it; yet the most significant fact about instinct is the fact that instinct complexes are variable and modifiable. Warren says of the sucking human infant, "This involves several different reflexes. The first is the bending movement of the child toward the breast, a reflex which may be stimulated by hunger or by sight or odor. Next is the grasping reflex with the lips; then follows the sucking reflex and finally the swallowing reflex. Each reflex action in this series furnishes a stimulus which leads to the succeeding reflex. The grasping movement of the lips is stimulated by the touch of the

lips; the sucking movement by the grasping sensation, and swallowing by the action of the milk upon the tongue, lining of the mouth, and glottis. This succession of response and stimulation is characteristic of instinctive behavior generally."

Such feeling is instinctive, but even in the very first act a highly complex process is meeting the emergencies of the situation. Later, varying with the conditions of the home, sucking gives way to drinking from a cup; this to the act — involving thousands of reflexes — of the taking of the milk with a spoon; this to the handling of solid food; this to the appropriate use of knife and fork and the adoption of other table amenities; this to the control of appetite; this to the pursuit of food and the development of the appetite of the epicure and the discrimination of the food concerned.

Classification. — The classification of instincts differs essentially from the classification of reflexes in that the former is usually based on group activities, such as the nutritive, the reproductive, the defensive, the aggressive, and the social instincts; these may then be subdivided to represent smaller group instincts, such as feeding, mating, flight, rivalry, coöperation; and subdivision after subdivision may be extended until we reach the specific and relatively simple reflexes. For practical purposes we can make as many classifications of instincts as we have purposes to be served and, though all may be different, each may be right. Thus, we may classify them, like emotions, into those that tend to preserve the individual, those that tend to preserve the race, and those that tend to preserve the social group.

Or, with McDougall, we may link them with typical emotions, as (1) the instinct of fleeing and the emotion of fear, (2) the instinct of repulsion and the emotion of disgust, (3) the instinct of curiosity and the emotion of wonder, (4) the instinct of pugnacity and the emotion of anger, (5) the instincts of self-abasement and self-assertion and the emotions of subjection and elation, (6) the parental instinct and the tender emotions, and other groups of less well-defined emotional tendencies.

It has been customary to recognize a series of instincts, as distinguished from reflexes, and use these as explanatory principles, particularly in sociology, art, and education. There has been much wrangling about the nature and number of these instincts and even their existence has been questioned. Our present view gives instinct a large place in life, both animal and human, in that it recognizes its ever-presence in all mental life in the form of inherited reactions which form many of the ingredients of our daily mental life. It enables us to recognize the large and permanent rôle of "original nature" in character, skill, capacity, ability; emotions, impulses, and sentiments; even in thought and deliberate action. We shall not explain a few traits by instinct, as has been customary, but we shall regard instinct as one of the large factors in the account of each and all acts of mental life. This position becomes particularly significant in the study of the relative value of heredity and environment in mental growth, education, and character. The recognition of countless inherited reactions in our perception, imagination, thought, feeling, and will sheds a strong light on the old controversy in

that it throws into relief the "original nature" as the permanent and dominant aspect of all our accomplishments.

EXERCISE. — *Now write a full and concise definition of instinct in terms of the positions taken in this chapter.*

CHAPTER XVI

HABIT

Habit formation.

EXERCISE. — (*a*) *Spend exactly twelve minutes in writing the word* S c i e n c e *upside down, with best combined effort for speed and accuracy. Write full lines across the page as in letter writing, and preserve the entire record.*

(*b*) *In a similar manner, spend two minutes in writing the word* P s y c h o l o g y *upside down. Compare the quality and quantity of your achievement with that of others in the class.*

In this exercise you probably observe, among other things, that you first encountered difficulty, confusion, and failure. You made many kinds of mistakes; you were uncertain about the result; you were interested in many elements of the new situation; you struggled with great effort. You were conscious of each part of every letter: you thought of sharp turn and round turn; turn right, turn left; move hand up, move hand right; long stroke, short stroke; light line, shaded line; letting hand go with a dash, or tracing slowly; hesitating in the middle of a stroke, and considering ways of doing it differently. You bit your teeth, puckered your lips, twitched your eyelids, fidgeted with hands and feet, braced up, and grasped the pen with conscious effort. You looked with painstaking care, were conscious of kinesthetic sensations, imaged the letter and movement in anticipation, were moved by feelings of failure and success, blamed and praised

yourself in turn, strained your attention, exerted your full will power.

Indeed, at the beginning, your efforts were often ill directed, complicated, laborious, crude, slow, and uneconomical; but, even within the short period of twelve minutes, you made great progress, rapidly acquiring accuracy, simplicity, and speed in movement and economy of effort in the new handwriting. You have acquired a new habit. By comparison with others, or with norms, you may also know something about your relative capacity for acquiring this sort of skill.

That this habit is really a series of habits was demonstrated in Ex. *b*; for many of the habits acquired in Ex. *a* were carried over to Ex. *b*, so that you probably got as good a result with a longer word in two minutes in the latter exercise as you got in twelve minutes in the former.

In the same way you can readily see that you really entered upon Ex. *a* already equipped with a vast array of established habits without which the task would have been impossible in such a short time. And, as you reflect upon it, you recall that one of the difficulties encountered was the necessity of breaking up rigid old habits of writing right side up.

You acquired a new habit chain, or skill, in a short time because you applied yourself efficiently. With but little further practice you would be able to write the word as well upside down as in the usual way. In the same manner you could acquire mirror writing, the ability to write with the left hand, with both hands simultaneously, to write with both hands and carry on a conversation

at the same time, and as many similar tricks as you would have the interest and will power to train for.

This exercise in learning is typical of what has taken place in the entire process of your physical and mental development. Your psychophysical growth, from earliest infancy, has been one continuous process of acquisition of skill through the progressive building up of habit chains, each new achievement being based upon previously acquired habit links.

Nature of habit. — Learning, from infancy to old age, takes two forms: acquisition of facility of action, both physical and mental, and the acquisition of ideas and concepts. The former we call habit, the latter knowledge. Fundamentally these two aspects of the learning processes are alike from a neural point of view, in that they both consist of established neural paths; but it will simplify our study to consider them separately. In this chapter we shall limit ourselves to the former.

On the basis of the above exercise, we may define habit as an acquired skill which tends to make an act purposive, simple, quick, uniform, easy, and economical. Or, stated from a neural point of view, the formation of a habit is the formation of a new pathway through which the nerve impulse may course to its proper destination over a direct and short route, well bridged at the synapse, rigid, and relatively independent of higher pathways. Trace the parallel in these two statements and interpret your experience in the exercise in terms of each of these in turn.

Mental development takes the form of the progressive building of automatisms, self-acting systems in which

situations are met without the intervention of consciousness. The tendency in maturation is ever in the direction of reducing consciousness of detail in an act to its lowest level. As we have seen in the exercise, what at first requires the strain of the higher mental powers is gradually reduced to a lower, easier, and more stable course, so that, for the acquisition of each new habit, the higher consciousness is set free for the new tasks, since each acquired skill tends to operate automatically. It has been said that a perfectly formed character, if such there were, would be a perfect automatism. That is to say, action, however complex, would take on the characteristics of the reflex act; namely, purposiveness, simplicity, ease, speed, uniformity, and economy of effort. Thus, walking is at first acquired through persistent conscious effort. But when we have once learned to walk, habit adjusts the thousands of muscle fibers for each step in such a way as to serve the need of the moment; if no obstructions are encountered, each foot in turn comes forward promptly to meet the new situation mechanically; the walking takes on a uniform, pendular swing, is easy, and may be gracefully continued without conscious effort while the mind is otherwise engaged.

Habit may be either physical or mental, or both, as in habits of walking, habits of thinking, or habits of talking. Habits are formed at all mental levels. Hence we have habits of observation, of visualizing, recalling, relating things, taking emotional attitudes, and responding in physical movements. Habit is, therefore, not only an occasional outburst of action, as in the habit

of swearing or the habit of promptness; it is an all-pervading tendency of all behavior in our daily life. For although it is contrasted with consciously directed actions, it is present in the component forms of all higher forms of action, as in reasoning or acting deliberately upon choice.

The term is used in a double meaning. Thus, in eating with a fork, we speak of the habit of using a fork as opposed to knife or spoon. But the manipulation of the fork itself involves a complicated chain of specific habits. If it were not so, our food would miss its destination.

Explanation of habit. — The explanation of habit formation is to be found in the laws of association. The law most generally effective is the law of frequency, which we call practice: indeed, practice has been called the law of habit. To understand the psychology and physiology of this phase of the learning process, then, we have only to appeal to the psychological and physiological interpretation of association as treated in earlier chapters.

The modification of the nervous system through habit formation is made possible, as we saw in Chapter XIII, by the unique provision that neural paths are not formed by the actual growing together of successive neurons in the chain; the neurons lie in bunches like live wires, most delicately insulated in such a way that a new path may be forced through at any synapse, and old paths may be blocked by interference or disuse. Thus we must think of the mental development through habit formation as taking place through the delicate

changes in conductivity for the transmission of nerve impulses at the synapse.

In explaining habit, we must apply our general theory of the relation of mind and body. All habits, physical and mental, might be interpreted and explained consistently and fully in terms of neural processes if we had access to the facts. Our interest is, however, not in these, but in behavior, in what is accomplished, and in the experience of accomplishing. Discussions of habit are, therefore, usually cast in psychological terms.

Instinct and habit. — The habitual act is like an instinctive act; but the two differ in their origin, one being perfected in the life of the species, and the other in the life of the individual. The infant comes into the world with his mind a *tabula rasa; i.e.*, a blank, so far as knowledge or ideas are concerned. But he comes well equipped with organized systems of instinctive capacities, sensitive to stimuli, ready to "store up" experience, and to preserve life. Instincts being modifiable, the development of the individual takes the form of a progressive adaptation of the inborn capacities to fit them to the growing needs of the individual. In this process there is no leap or break: the transition from one step to the next is gradual and natural as we have seen, *e.g.*, in our discussion of the modification of the feeding instinct. Thus habit is instinct or reflex progressively adapted, enlarged, and extended on the basis of individual experience.

There are characteristic periods in the life of the individual for the formation of the various types of habit. Thus, the ordinary habits of orientation through use

of the senses with associated muscular response in reaction to what goes on in the environment are developed early in the life of the child. The child, upon entering school, has already acquired the serviceable use of all his senses, even in complicated forms, such as the seeing of relief, distance, and direction; the habit of anticipating in images, the habit of expecting natural sequence of cause and effect, or making inferences; the habit of natural attitudes of approval and disapproval; even the habit of using his will power. And for all these purposes his muscles are relatively well mastered so that the vocal organs perform almost inconceivably intricate adjustments in speed; the hand is an adequate tool of the mind, and the muscles of movement, posture, and all other forms of adjustment are relatively at easy command.

Learning in school and after school consists essentially in the acquisition of specific skills for which fundamental elements were acquired in early childhood. Thus, in the mastery of marbles, baseball, bat, racket, oar, golf stick, or trigger, each new habit is essentially a new chain made from links in the vast fund of fundamental habits. But when we attribute so much to fundamental habits early acquired, we are only stressing the fact that these are essentially "racial habits" or instincts which represent neural paths fixed through millions of years of evolution. In other words, the fundamental habits, such as control of sense organs and muscles, and countless sorts of adjustments are essentially instincts which have established themselves by the outlet furnished in early habit formation.

Capacity and ability. — Two common words, capacity and ability, have acquired technical meaning in modern psychology. Capacity refers to organic equipment acquired in the process of evolution (*i.e.*, adapted organs with the instinct to use them); ability refers to habit or skill acquired through the use of capacity in the life of the individual. Thus, we are endowed with a well-organized series of capacities for control of finger movements; we acquire the ability to use them in all sorts of skilful and deliberate finger action for specific ends, such as threading a needle or playing the piano. We are born with capacity for seeing form; we develop ability for the meaningful perception of form through progressive use of this capacity. We are born with capacities for memory, imagination, and deliberation; we cultivate ability to use these capacities. The distinguishing mark of capacity is that it is elemental, by which we mean that it is a comparatively simple unit, is exercised very early in play, and is relatively independent of age, training, and general intelligence. The sense organs and the muscles with their inherited control have as good capacity before education as they will ever have afterward. Education, growth, and effort result in the development of abilities — not in the improvement of natural capacities. The character of the original equipment for any process, both as to quality and quantity, has been called a "personal equation," and may be regarded as an index to the natural resources of an individual in a given capacity.

Habit and attention. — The most significant feature of habit formation is the gradual reduction of the need

of attention and effort. The lowering of the attention is, however, perhaps mainly a matter of degree, since consciousness seems to be more or less on the alert, or in readiness for functioning, even with our best acquired habits, such as walking, chewing, and various forms of highly perfected skill in the handling of tools and instruments.

On the other hand, certain habits or habit chains demand attention of the most effective and spontaneous kind. Stout gives the example of fencing:

"The most expert fencer can not afford to allow himself to be absorbed in an irrelevant train of thought while he is engaged in a duel. On the contrary, the keenest watchfulness is required. The reason is that only certain component parts of the action have become thoroughly habitual; these do not of themselves require to be attended to. The practised fencer has not to think about the proper modes of thrusting and parrying; what requires attention is the tactics of his opponent. As soon as he discerns by sight or feeling the direction in which his antagonist's rapier is moving, the proper reply is made automatically. Thus, attention is demanded for the proper combination of a series of movements which are severally automatic, a combination which has to be adjusted to constantly fluctuating conditions."

"**Habit a fly-wheel of society.** — Habit is thus the enormous fly-wheel of society, its most precious conservative agent. It alone is what keeps us all within the bounds of ordinance, and saves the children of fortune from the envious uprisings of the poor. It alone prevents the hardest and most repulsive walks of life from being deserted by those brought up to tread therein. It keeps the fisherman and the deck-hand at sea through the winter; it holds the miner in his darkness, and nails

the countryman to his log-cabin and his lonely farm through all the months of snow; it protects us from invasion by the natives of the desert and the frozen zone. It dooms us all to fight out the battle of life upon the lines of our nurture or our early choice, and to make the best of a pursuit that disagrees, because there is no other for which we are fitted, and it is too late to begin again. It keeps different social strata from mixing. Already at the age of twenty-five you see the professional mannerism settling down on the young commercial traveller, on the young doctor, on the young minister, on the young counselor-at-law. You see the little lines of thought, the prejudices, the ways of the 'shop,' in a word, from which the man can by-and-by no more escape than his coat-sleeve can suddenly fall into a new set of folds. On the whole, it is best he should not escape. It is well for the world that in most of us, by the age of thirty, the character has set like plaster, and will never soften again." (James)

Principles of habit formation. — The principles that govern habit formation are essentially the same as those that govern the acquisition of knowledge. In the interest of economy, some of these are set forth together in the following chapter in the learning process. That chapter will serve well also to show the relationship between habit and memory. The laws for the formation of habit may also be applied in the interest of the prevention of the formation of undesirable habits. In our "mixed nature" the avoidance of evil is often as important as the acquisition of the good. But in general, pedagogically, the best way to avoid the formation of evil habits is not to think about that, but to have our minds bent upon the acquisition of the good and desirable.

We are very wasteful in the use of our capacity for good habit formations. If, for instance, you pursued every goal with the same persistent effort that you gave for twelve minutes to the writing of a word upside down, most wonderful results might be attained. We fail in the attainment of high achievement in the way of skills largely because the normal life of the average individual is a sort of dawdling, aimless floundering, without fixed objectives. Observe the skilful stenographer, the artist at work, the expert tradesman, the phenomenal chess player, the mathematician, the athlete, and you will see the exhibition of as many skills, each having had normal development through persistent practice. We are endowed with so infinite a variety of capacities, and the world is so interesting in its play of variety to the normal individual, that, like the traditional ass which died of starvation for want of decision between two haystacks, we often fail to make use of the opportunities for the acquisition of countless most interesting and valuable skills which are quite within our reach. The same is true of habit in little things, things which might be mastered with but slight concentrated effort, but in which we remain helpless and indifferent throughout life. Were it not for nature's wealth of provisions through instinctive tendencies, we should grow quite helpless, as a relatively small number of the necessary skills for normal life are acquired through serious effort and direction. The majority come through stress of circumstance and natural, passive bent of mind — by chance.

The goal of education should be the early formation

of the habit of forming habits. Among such are the habits of concentration upon a task in hand with persistence, relaxation after sustained effort, interest in achievement, success in mastery, self-confidence, ambition, and forethought in planning.

CHAPTER XVII

THE LEARNING PROCESS

EXERCISE. — *This chapter is a sustained exercise in memory training. Go through it slowly and critically once and put each rule into practice after it has been encountered. At the end of the chapter, without looking back, write a skeletal outline, listing in abbreviation all the facts from the chapter that you can recall.*[1]

President Porter has said that a good memory depends upon a good digestion, a good logic, and a good conscience. Health, the power of mental application, and an upright life — these are the fundamental conditions of good memory. We may take for granted the first and the last of these conditions, which come within the domain of physiology and ethics respectively, and consider the psychological factor of mental economy.

A good memory is not one that remembers everything. If one were doomed to remember everything that came within his experience, he would find himself hopelessly swamped, distracted, possibly insane.

The test of a good memory is that it shall be serviceable; that the mind shall be furnished and ready with just the sort of facts which may be needed, and free from the encumbrances of useless, irrelevant, or dis-

[1] The present chapter taken from the author's *Psychology in Daily Life*, with generous permission of the publishers (D. Appleton & Co., N. Y.), is introduced here as a sustained illustration of applied psychology of the learning process, stripped of all technicalities. It should be regarded as a *practical exercise* for the chapters on Habit and Memory.

tracting material. In addition, these facts should be accurate, "faithful to the original"; they should be long retained, if necessary; they should come promptly, easily, and conveniently. Improvement in memory will be judged with reference to these and allied standards.

A valuable body of knowledge in regard to the nature of the memory process and the principle of acquisition has been accumulated by experimental methods. Instead of summarizing these facts in a technical way I shall formulate a series of simple rules of memory-training in the language of every-day experience, in so far as possible, in harmony with these facts. The chief statements will be put in the form of commands or rules, not for the sake of exhortation, let it be emphatically said, but for the sake of clearness and brevity.

These rules may be grouped under four general heads: Impression, Association, Recall, and Recognition. Under these only the more typical rules are considered; details or qualifications must be omitted. This is not a memory "system"; it is merely a series of selected illustrations. The artifice of a "corollary" under each rule is not taken in a rigid, logical sense, but merely serves to suggest, through a single illustration, something of the rich radiations of a given rule.

I. Rules of Impression

1. **Select your field of interest** (Selection).

Corollary: Dare to be ignorant of many things.

Nature provides for rigid selection in all directions by setting limits to our capacities, thereby forcing in-

stinctive selection of interests and favoring the formation of ruts. We may, however, vastly enhance the serviceableness of our memory by a deliberate selecting of life interests which we shall take seriously by our nature and choice as well as by the force of circumstances. To remember serviceably is to reach promptly the data desired; and, to do this systematically, the mind's eye must be trained to focus automatically upon the desired memory-object.

If one is to be a banker he should train himself actively and systematically to remember facts pertaining to banking: not that he should limit his interests to banking; he must have life interests, such, for example, as pertain to social life, to health, or to intellectual pursuits. But these interests should be only a few out of the many toward which he might be inclined by nature. It is the man who keeps his mind on banking during banking hours who becomes a financier. If he attends in the same way to other obligations out of banking hours he will be also socially attractive and will find satisfaction in a larger life. This is true alike in the humbler walks of life and in its highest pursuits.

Occasional and casual selection of memory-objects does not strengthen memory power, but on the contrary often weakens it. To strengthen memory the selection must follow a system of habits based upon life interests. This implies that the selection shall be made in large units of interest; that intruding interests shall be eliminated by habits of application; that the mind, free from anxiety, shall feel itself adjusted to the situations which confront it.

Mills College
Mills
College

2. **Intend to remember** (Intention).

COROLLARY: Trust your memory.

An Indian woman began her business career by trading in primitive fashion with the pioneers in a village of Colorado. The population grew gradually, and with it her trade expanded into a large general merchandise establishment which supplied the community with everything from food, clothing, and jewelry to threshing-machines. This woman remained her own bookkeeper. She maintained an extensive credit account, but kept no books. She trusted her memory; and it served her well because the demands upon it increased so gradually that she never lost confidence in herself.

To intend to remember means to fix the impression with confidence. To trust memory means to have the habit of intending to remember. Sporadic intentions are unreliable. The intentions that count in life are habitual — constant, not casual. When the intention to remember has become a habit, memory serves with little effort; instead of being a matter of concern, remembering becomes a matter of comfort and ease, just as does truth telling. Such is the natural habit of a good memory. We enjoy things, we observe distinctions, we think truths, trusting that they are ours; and our memory serves us well.

3. **Attend to the selected object** (Attention).

COROLLARY: Secure the most effective form of attention.

Put yourself into such a channel of life that what you need to remember is that in which you are naturally interested.

The majority of college students who are unfit for study might be discovered by this criterion: "Has this student a natural interest in that which he is trying to learn?" College authorities might do well to apply this test rigidly early in the course and eliminate those who find no natural interest in their studies, thereby encouraging them before too late to seek other channels of education in which they would find themselves effectual. The charge to the entering freshman should be: "Learn that which you care for; and, if the college course does not arouse in you a feeling of fitness for the work, go elsewhere; for there is something wrong either with you or with the college."

Our rule is, therefore, not the trite admonition: "Pay attention." That rule has its value; but voluntary attention is seldom more than a precarious makeshift in the ordinary work and experiences of life; it is too rare and costly. Voluntary attention is one of the highest and most indispensable achievements of man, but the attention that serves the steady flow of the stream of consciousness must be spontaneous and yet semi-automatic. It may be called derived primary attention because it has been favored and encouraged until it has become second nature. Attention to a dog fight is passive, but attention to the traits and achievements of dogs from the point of view of the dog-fancier or the animal psychologist is secondary passive, because it flows from a consciously directed natural interest.

This rule affects the entire plan of our daily life. Power depends upon leverage. In memory, as in all other forms of force, the main thing is to get a leverage;

and the best leverage for memory is a genuine interest. The modern movement in vocational direction will do much to increase the serviceableness of the memory-grasp of those who are wisely guided into natural channels of life-work.

4. **Grasp the elements** (Elements).

COROLLARY: Let essentials stand out in a relief.

To remember the above three rules after they have been understood, it is not necessary to fix the more than five hundred words comprised in the statements and illustrations. A single key-word for each rule will suffice; for example, selection, intention, attention. To impress the illustrations and interpretations in their elements the mental note might run something like this:

Selection: nature's selection, banker, habit;

Intention: squaw, habit;

Attention: studies, derived primary, leverage.

The key-word for each rule must represent a concrete unit of thought; and the three key-words for the respective rules must be grasped as a single unit embodying the common element of the three ideas — namely, concentration upon the impression.

The good reader will have analyzed in this way, because it is his way of reading, and at this point the thought stands out concrete and logical; whereas the inferior reader will have "plowed through the stuff" in a helpless way and can not retrace his steps, because he has not grasped the elements in the reading. The effect of observing and of thinking in terms of the elements involved is not merely to reduce the number of necessary words or symbols, but rather to give per-

spective to the essentials. It affords something to take hold of.

5. **Trust the primary impression** (Primacy).

COROLLARY: Master as you go.

The facts relating to the attention wave and the proper mastery of elements, as described above, have a striking application here. If you want a good, clear picture by time exposure take one exposure of the required length. Do not blur by trying to get a summation of impressions. So, in making a mental picture, observe so as to grasp the object in a single firm impression. Trust that impression and seal it with the intention to remember.

This principle is opposed to the rote method. To memorize a poem do not merely grind it over and over in a mechanical way, but, after a preliminary reading, read it logically; go slowly, step by step, intending to learn it in the best way; attend to the task with a mind prepared to discover the essential elements of the structure and determined to make the first impression trustworthy.

The rules of memory may be represented by a pyramid; the side of the pyramid, which we have now approached, is designated Impression. Reading from the base upward, the steps or elevations rise in this natural order:

Primacy: Trust the primary impression
Elements: Grasp the elements
Attention: Attend to the selected object
Intention: Intend to remember
Selection: Select your field of interest

6. **Practice systematic observation** (Practice).

COROLLARY: "Do it now."

Ordinarily the development of memory is left to chance, to a casual issue. We know only a few of the laws of memory and make but little effort to apply these. We grow up so gradually that there is ordinarily no particular moment at which the value of practice is forced upon us. In the training of the young there might well be introduced some instruction in the principles of memory training to be followed by a régime in which the command, "Do it now," could be enforced. Systematic training yields remarkable results, whether the memory be originally very good or only ordinarily retentive. It is not necessary to set drill exercises on mere drill material, nor is it necessary or desirable to follow any of the hundreds of artificial systems sold by professional trainers of memory. The thing to do is to learn the fundamental facts about memory and then simply apply them as we go about our ordinary duties of the day. No more economic lesson could be set than to learn by doing the very thing you are to do. Meet the situations which are a part of your life routine with the habits of interest, trust, discernment, thought, and application and you will practice the above six rules and many others with a corresponding growth in efficiency. Crown the pyramid of Impression, then, by the capstone, Practice.

II. RULES OF ASSOCIATION

1. **Recognize relationships** (Relationships).

COROLLARY: Be familiar with the laws of association.

It is announced that a friend is to be married in June. The moment I hear this I say to myself: "How appropriate! June is the wedding month; it is the month of roses; it is the month which symbolizes the blossoming into life. I cannot fail to remember it." In this way we ordinarily relate impressions, be they ever so isolated or abstract.

Our rule does not imply any one formulated application of association but rather the habitual attitude of appreciation. But this power of appreciation is vastly increased and strengthened by insight into the nature of the laws of association. Despite their controversial history among psychologists, the rules of association are in fact surprisingly few and clear to common sense.

Our rule is to observe the relations of impressions. Knowledge of these possible relations facilitates the presentation of facts and supplies us a means of holding them for recall. One illustration must suffice. The law of similarity is the basis of all scientific classification; without it there could be no science. The botanist can recognize and recall thousands of plants because he has formed the habit of seeing relationships. One plant is like another plant in this, and that, and another respect; therefore they belong to the same class. Instead of remembering the hundred or thousand individual plants, the botanist remembers only one representative plant and the relationships within the class to which it belongs. This is often pictured in a more or less composite image; but the consciousness involved in that image is the consciousness of relations. Our first rule

of association is the general charge to set your facts in a system of relations.

2. **Form habits of analyzing** (Analysis).

COROLLARY: Learn by thinking.

This rule may be variously illustrated. It is a favorite principle in the modern mnemonic systems of which the system of Loisette is a good illustration. Loisette was a famous memory teacher in New York. The main secret of his system (and it was sold as a secret) consisted in a somewhat artificial application of this principle. Taking the three laws of association which he called inclusion, exclusion, and concurrence, he devised a progressive series of exercises in which the learner acquired great ability in discovering clear-cut relations; *i.e.*, the ability to perceive and recall in terms of such relations consciously recognized, yet directly and easily as one sees directly and without effort the color of a flower. The following is his illustration of the meaning of the first law, inclusion:

INCLUSION indicates that there is an *overlapping of meaning* between two words, or that there is a *prominent idea* or *sound* that belongs to both alike, or that a similar fact or property belongs to two events or things as, to enumerate a few classes:

Whole and Part. — (Earth, poles) (ship, rudder) (forest, trees) (air, oxygen) (house, parlor) (clock, pendulum) (knife, blade) (India, Punjab) (14, 7).

Genus and Species. — (Animal, man) (plant, thyme) (fish, salmon) (tree, oak) (game, pheasant) (dog, retriever) (universal evolution, natural selection) (silver lining, relief of Lucknow) (Empress, Queen Victoria).

Abstract and Concrete. — (The same quality appears both in the adjective and in the substantive.) — (Dough, soft) (empty, drum) (lion, strong) (eagle, swift) (courage, hero) (glass, smoothness) (gold, ductility) (sunshine, light) (fire, warmth).

Similarity of Sound. — (Emperor, empty) (salvation, salamander) (hallelujah, hallucination) (cat, catastrophe) (top, topsy).

Simple inclusion embraces cases not found in either of the foregoing classes, but where there is *something in common* between the pairs, as (church, temple) (pocket, black hole).

The first exercise consists in learning the following list of ten words in a single reading by aid of the recognition of these principles of inclusion :

Building Dwelling	Genus and Species.
Dwelling House House	Synonyms.
House Parlor	Whole and Part.
Parlor Partridge	Similarity by Sight and Sound.
Partridge Feathers	Whole and Part.
Feathers Light	Concrete and Abstract.
Light Lighterman	Sight and Sound.
Lighterman Lord Mansfield	Sight and Sound.
Lord Mansfield Field Hand	Sight and Sound.

Such analysis of the words and their relations serves to fix the relationship, and it is possible to repeat the list forward and backward after one such reading. Applying this principle to the remembering of numbers, Loisette gives such illustrations as these: the height of Pikes Peak is 14,147 feet; observe that the number consists of two 14's and a half of 14. Fujiyama, the noted volcano of Japan, is 12,365 feet high; observe that this number is made up of the number of months and of days in the year — 12 and 365.

This may serve as a partial illustration of a memory system which possesses some merit. As a matter of fact, now that it is printed in a book and sold for a dollar, very little use is made of it. When it was sold for fifty dollars or more, with a pledge of secrecy, the buyer actually followed the directions in order to get what he paid for; and he often got it. Merely to read the book will be of no avail. If there were some contrivance by which one could extract fifty dollars for the chapter on memory training which you are now reading, its usefulness would be greatly increased.

3. **Force concrete imagery** (Forcing).

COROLLARY: Fix the first fancy.

By following this rule a person with ordinary memory may learn a list of fifty or a hundred disconnected words in a single reading so that he can repeat the whole list either forward or backward. Try it. Here are the instructions: Have some one read a list of words slowly, or uncover one word at a time by yourself, and at the very first impression that you get from the words observe some connection (the more bizarre the better) between the new

word and the preceding one; picture this relationship concretely and add a new section to the group image for each new word added to the chain of words; fix the first fancy of each relationship, and image it boldly. But before we try the experiment let us illustrate the procedure with a short list of words.

Boy — I see a little barefooted boy

Grass — walking in the tall grass;

Glass — the stalks of grass crackle like glass under his feet:

Pike — therefore he is glad when he sees the open pike.

Scissors — his little legs clip like scissors,

Ventilation — and his lungs get good ventilation,

Bird — for he flies like a bird

Nickel — and swings his nickel-plated rod

Fury — like fury

Gear — because he is now in gear with nature.

Each learner will have a different set of associations. It is important that he should use his own, and, so far as possible, use the first association that comes to his mind. It is the concrete imaging of the fancied situations as a unit that welds the words together in memory.

As a matter of fact, this is the method we naturally employ in ordinary routine memory. There is an automobile accident, and a witness is called to report. He can give a fairly good report because he has a definite notion of the relations of figures in the scene: the chauffeur looking back, the horse struck on the front knees, the lady's hatpin flying in the air, the first aid to the injured, horses and rider, etc.

4. **Grasp in large units** (Large Units).

COROLLARY: Remember ideas, not words.

In one sense memory improves with mental growth because we learn to think in larger and larger units. A little boy goes with his father to a museum and sees a collection of shells. The boy sees and will remember a few forms which strike his fancy, but the father, who knows his systematic classification, is able to give a better account of the group, for he learned by large units; whereas the boy treated each shell as an individual object, with the exception possibly of obvious similarities.

5. **Observe synthetically** (Synthesis).

COROLLARY: Build elements into a whole.

The rule is a rule of accumulation. In reading for the purpose of memorizing, the proper procedure is to read each word in the sentence and, before proceeding further, to grasp the sentence as a unit; then, treating the sentence as an element in the same way, to grasp the paragraph as a unit of sentences.

To bind the impression once firmly grasped, be familiar with the bonds that fasten new acquisitions to what you already have, examine these ties deliberately and make sure that they bind; clinch with some additional ties — the first that you find in your own rich personal supply; make each bundle as large as you can, and then tie all the bundles together. See our pyramid:

Synthesis: Observe synthetically
Large units: Grasp in large units
Forcing: Force concrete imagery
Analysis: Form habits of analyzing
Relationships: Recognize relationships

6. **Practice.**

As in impression, so in association, knowledge of these laws is of no use unless it be put into practice. In itself, the knowledge is not power. One trial does not give power. The power of association is fully effective only when it is so firmly ingrained by practice as to operate automatically and irresistibly, and therefore with ease. Mounting the pyramid from the side of Association, we rise from another side to the original capstone, Practice.

III. Rules of Recall

1. **Be persistent in the effort to recall** (Persistence).

COROLLARY: Seek clues and follow them: try.

This is the logical sequel to the rule of impression, "Intend to remember." It is a very common occurrence that we have established good impressions in association and yet fail through negligence in the recall. If the memory image is not at command as soon as sought, we all too readily conclude that we cannot reach it.

Ability to recall is not, like the ability to lift or the ability to hear, restricted by any sharply limiting sense organ. If the memory image comes to me immediately, that is largely a matter of chance; I chance to have in mind the impression or idea which has such associations with the image sought that it draws it out promptly. Our rule encourages us to use all our effort and ingenuity in search for an association which shall draw out the desired image. Mere blind persistence, often the mere lapse of time, brings out the proper association; but vastly more can be accomplished if the effort is made to review systematically the events which lead up to the

desired link. We must retrieve, not merely flush, the game.

Here again the importance does not attach so much to the isolated effort as to the formation of the habit of discovering clues and following them. Training in this will place at one's command a power of insight into relations and a power to follow lines of association tenaciously, yet with decreasing effort.

2. **Repeat the recall often** (Repetition).

COROLLARY: Never miss the opportunity of seeing a good friend.

It has been said that to learn a technical subject, such as anatomy, one must have forgotten it several times and have learned it over again. That is what happens as a rule in our casual occupations, but it is very wasteful. The more economic way is to trust the initial impression; hold it until it is fixed by some bond of association; then, instead of repeating the impression, recall and repeat the recall as often as may be necessary. One recall is worth more than a dozen impressions because it is the recall and not the impression which we aim to fix.

This rule has two distinct applications. In the first place, it gives us the procedure for the building up of a complex impression, such as a long definition or a poem. As we have seen above, the impressions should be cumulative; that is, the reader should learn one after another the elements of the impression singly or in simple groups, and then progressively unite these until the complex is grasped as a whole. In the welding together of these elements in the impression, the elements should be handled in recall, and not in repeated impressions of parts. Thus

the impression in the case of complete memory object passes gradually by steps from impression to recall, and the impression is not complete until the large units can be held firm and true in clear recall.

In the second place, the rule applies to the securing of permanent retention. Instead of forgetting the anatomy and then going back to learn it over and over again, the economic way is to review in memory, instead of in impression, as often as may be necessary to prevent the intrusion of errors in recall. There are, of course, exceptions to this rule. I learn the streets of a city for guidance on a visit, but if I am not to visit that city for twenty years it would be waste of energy to keep that memory alive. The rule applies, however, to all cases in which we desire to keep the remembrance continuously available.

3. **Be rigidly exact in recall** (Rigidity).

COROLLARY: In forming a habit, suffer no violation.

The ability to recall a specific event is a habit. Therefore, in practicing recall, all the laws of good habit formation should be obeyed. Easy-going and slovenly recall is doubly wasteful. This applies particularly to the preceding rule and places additional emphasis upon the first impression.

4. **Keep out the irrelevant** (Relevance).

COROLLARY: Concentrate on the recall.

If all the memory rules should be reduced to one, that rule might be expressed in the single word, "Concentrate." The ability to concentrate attention upon the act in hand is a criterion of a well-developed mind. Suppose that you are preparing for an examination in history.

You are rehearsing (not reading over again except to verify) the principal groups of facts to be remembered; each and every individual fact has a rich fringe of associations reaching out into all sorts of matters which have nothing to do with the facts of history, and each of these offers avenues for distraction. Our rule, humiliatingly simple, says: Do not let your mind wander from the matter in hand — these related historical facts. What a waste of human effort results from the violation of this stern rule through lax habits and inherent laziness.

5. **Rest economically** (Rest).

COROLLARY: Respect the attention-wave.

It is a familiar fact that we can recall best when the mind is fresh after rest. It is good economy to take a period of rest before a pending serious tax of the memory. But this rule has more important applications. Experiments have shown that we work best mentally when we work periodically rather than in continuous strain. Consciousness has a natural periodicity; the more we favor this periodicity, the more effective we become. The periodicity may be traced in second-waves through two to ten seconds, minute-waves consisting of groups of second-waves, and hour-waves such as the well-known periodicity of the day. Now in recall — and most of our memorizing, as seen above, should be more or less in the nature of recall — we should reach back intensively for a short time and then relax completely for a periodic rest. This periodic activity in simple waves may then be grouped in larger waves. It is a notable fact that those who seem to work the hardest enjoy the most complete relaxation.

We have now approached the pyramid from a third side, Recall, and see in relief the five steps:

Rest: Rest economically
Relevance: Keep out the irrelevant
Rigidity: Be rigidly exact in recall
Repetition: Repeat the recall often
Persistence: Be persistent in the effort to recall

6. **Practice.**

Once more, that which counts in the improvement of recall is systematic practice in recall. So we mount again upon the hard and solid capstone, Practice.

IV. Rules of Recognition

1. **Recognize the memory image as you would a friend** (Recognition).

Corollary: "Cut" your friend and he will cut you.

Our thoughts are the children of our minds; our memories are a part of our past. Memory is never complete until the feeling is present that this event has occurred before. It must be recognized as a part of the past but with reference to the present personal associations. This recognition is seldom complete. It is usually based upon a feeling of familiarity and power, and takes the form of a simple belief.

The mere recall is usually automatic and results in action without the intervention of consciousness. Most of my daily activities are in a sense acts of recall, recognized. To complete the conscious memory this memory image must be singled out and recognized with warmth, as a friend is singled out from a passing throng, and greeted. Apply the principle of recognition in friend-

ship to the recognition of memories and they will be yours. Our children and co-laborers may be about us, but we do not stop to greet them, for they are with us continuously. Many of our most indispensable memories are always with us without intruding upon our time or attention. The rule should be: when memory images come which you desire to fix, greet them warmly and confidingly and they will return to you in time of need.

2. **Cultivate realistic imagery in recognition** (Imagery).

COROLLARY: Reinstate the original setting.

In meeting a person you shake hands with him, look him in the eye, speak a word, and seal the bond of friendship. So in recalling a friend do not merely entertain an imageless idea of him, but see him, feel him, hear him, feel yourself responding to him, let him stand forth in a natural setting of an earlier meeting and thus make the recognition realistic and tangible. Such experience takes the form of rich and vivid imagery and may be cultivated with success, even if this does not come spontaneously. Its effect is to make the recall intense and rich in detail. You will soon form the habit of having this reinstatement of an earlier meeting a specific one; it may be the first, the last, the most typical, or the most impressive. A memory is not complete until we can localize it in time and place, either directly or indirectly. This habit of concrete imagery has the advantage of resetting the event in the proper time and place, as though we were living the event over again in the original. As toward friends, so toward memories, our feelings of worth, recognition, and attachment reach out to them and bind them to us.

3. **Express the recognition in appropriate action** (Expression).

Corollary: Grow through self-expression.

If you desire to remember the name of a friend be sure that you speak it with full comprehension the moment you reach out your hand upon introduction. Then, when you recall him, recall him by name; and when you meet him again, do not merely say "Good morning," but speak his name as you did upon first meeting and in the recall. More than that introduce your old friends to new friends from time to time. The application of this principle of friendship to the events and things of daily life is close. The operation is the same as in business; a rule of economy becomes yours only if, in addition to learning it, you apply it to your business relations.

4. **Transfer from conscious to organic memory** (Transference).

Corollary: "From conscious effort to ready skill."

At first the memory of each step and each element should be focal in the consciousness of memory and imagination; but, as soon as the skill has been acquired, consciousness is free for other and for higher achievements. Organic memory retains and reproduces its facts so that they result in appropriate expression without the intervention of consciousness, and is therefore easy and reliable. The ability to transfer conscious memories progressively to organic memories is a requisite for great skill, not only in physical dexterity, but in all the higher forms of well-adapted mental achievement.

5. **Learn to forget the useless** (Forgetting).

COROLLARY: Keep your card-catalogue system alive.

Dead timber and the useless accumulate constantly. When an item in your card catalogue has completely outlived its usefulness you remove it. The business of life has its temporary transactions, whose records it would be wasteful to thumb every day after the transactions are closed. The efficient man is the man who lives in the present. It takes deliberate will power to let the "dead past bury its dead." As our first rule of memory was "Dare to be ignorant," so our last may well be, with all the emphasis we can lay upon it, "Learn to forget."

Forgetting: Learn to forget the useless
Transference: Transfer to organic memory
Expression: Express recognition in action
Reinstatement: Reinstate the original setting
Recognition: Recognize the memory image

6. **Practice.**

The power of a warm, rich, and serviceable conscious memory is nature's generous gift to all normal men. Practice does not create anything; it merely uses and strengthens. All that has been said of practice should be accepted in this sense: use, enjoy, and it will become and remain your possession. The warning of psychology is: Waste not. So from every side of our pyramid we reach the one all-binding capstone, Practice.

To summarize as an aid in recall, let us name the rules in the order given.

Impression	*Recall*
Selection	Persistence
Intention	Repetition
Attention	Rigidity
Simplification	Relevance
Primacy	Rest
Practice	Practice
Association	*Recognition*
Relationships	Recognition
Analysis	Reinstatement
Forcing	Expression
Large Units	Transference
Synthesis	Forgetting
Practice	Practice

The reader who has hung the above rules upon the catchword pegs or horns may now review in realistic imagery the legends on the four faces of the pyramid-pedestal, and see the whole crowned with the heroic figure of *serviceable memory*.

As the steps of the pyramid are merely parts of the same solid structure, so impression, association, recall, and recognition are merely aspects of the one complex process of memory; the principles here outlined are more far-reaching and interrelated than this statement would suggest.

Who yearns to mount the pyramid? Everybody. Who will mount it? Very, very few. And this is natural and perhaps right. Most of us have decided, mainly through acts of negligence, that the systematic improvement of memory is not worth what it costs. But that

does not alter the psychological fact that memory can be improved, nor does it alter the responsibility for its improvement.

Let us not blame our parents for the inheritance of a weak memory. All normal persons have sufficient capacity if only they will use it. To be concrete, the average man does not use above ten per cent of his actual inherited capacity for memory. He wastes the ninety per cent by violating natural laws of remembering. Memory is very responsive to training; it is a fit object for conservation. But what most of us attain or conserve is what nature in her beneficent provision preserves for us despite our gross negligence and squandering extravagance.

EXERCISE. — *After having written the memory test, reëxamine the rules critically and decide how many of them are worth putting into practice for the rest of your life.*[1]

[1] The result of the memory test would, of course, have been better had all the rules been known and practised from the beginning of the chapter. Would it not be worth while to master these principles at this stage and apply them in the study of lessons hereafter? To do so will require a special effort, but it will be a good investment.

CHAPTER XVIII

MEMORY

Point of view. — Memory may be viewed scientifically from three points of view: (1) as present consciousness of past events with recognition; (2) as including with this conscious memory all subconscious processes of the same kind; and (3) as a neural law of adaptation in living tissue. From the third point of view, it is generally held that every impulse leaves a trace; from the second point of view it is maintained that, other things being equal, what is demonstrated of conscious processes holds also for subconscious processes. While our description will be primarily in terms of conscious memory, we shall constantly bear in mind the application to the subconscious and the fact that, underlying all mental aspects, is the physical fact of neural disposition as involved in association.[1]

Elements of Memory

Conscious memory, as defined by James, is "the knowledge of an event or fact of which in the meantime we have not been thinking, with the additional conscious-

[1] **Order of Topics.** — It may have surprised you to find that the chapter on applied psychology of memory should have preceded the present one on "pure" psychology of memory. The reason for this is twofold. In the first place, we have already studied impression in sensory experience, images, associations, the neural basis of memory, and organic memory as instinct. In the second place, training furnishes a happy device for bringing into concrete experience a somewhat systematic illustration of how memory works. It remains for us in the present chapter then merely to gather odds and ends in a general review of the memory process to which we have been introduced in the last few chapters.

ness that we have thought or experienced it before." Memory even so narrowly defined is really a group of processes which we recognize in four major steps: impression, retention, reproduction, and recognition.

Impression. — Impression is really not a part of the memory process proper, as it constitutes the original experience, such as perception, action, feeling or thought; but no adequate account of memory can be given without taking it into account, because the mode of impression determines the survival value, particularly in organized memory of serviceable facts.

"Every impression leaves a trace. The meaning of this statement may be made clear by an analogy. An earthquake disturbs a body of water violently; a ship plying at the surface changes the distribution of the water; a single drop falling makes an impression, however small, and the continued falling of drop after drop causes great changes in the level and distribution of the water, but no drop disappears without a trace. Just so the conscious, strong, and relevant impressions make marked changes in the psychophysical organism; but the stream of processes in this organism is made up in large part of merged 'drops,' the countless faint impressions, each of which, though losing its identity, enters into the composition and cumulative flow of the ever-changing stream.

"Sentience, affection, skill, and character all rest upon an incomparably broader foundation of fact than that of the sum total of consciously experienced impressions. We are seldom judged by our intentions or the attitudes we strike; we are judged by the attitudes in which we are least concerned with the effect we are to produce. When we judge a man we seldom develop a rational opinion of him from an indifferent

point of view; on the contrary, we first fall into an attitude toward him, and then proceed to picture him to ourselves from that point of view, usually without being aware of the existing bent of mind or of the impressions which caused it. This is true not only in friendships and aversions, but as well in our rich life of feeling-attitudes toward objects, events, ideas, and ideals in life. The countless inflowing impressions have left their traces, which exist as forces or tendencies; our attitudes are in large part the resultants of such forces.

"At the present moment your consciousness is properly centered upon the reading of this chapter or upon some reflections suggested by it. But at this very time there is a mass of visual, auditory, taste, smell, temperature, strain, and pain stimuli pressing in upon you. Every one leaves a trace. You feel with compunction that your mind is wandering. There is a fleeting array of undifferentiated ideas and impressions passing through you. Every one leaves a trace; it changes the growing mind so that the mental content is different from what it would have been if any one of these impressions had not occurred.

"It is one of the great blessings of nature that so few of these traces reach consciousness in the act of impression, and that still fewer are ever consciously recalled as individual impressions. Rationality, endurance, discrete cognition, and action rest upon the fact that consciousness is selective, personal, purposive, and of particular things. And again, it is fortunate that the elimination is automatic and, therefore, easy and effective. If we should be conscious of all impressions strong enough to reach consciousness in a given hour we should become mentally wrecked. So sensitive is our psychophysical organism that it registers everything, and so wonderfully are we organized that we can utilize stored-up experience with but slight expenditure of conscious effort." (The author's "Psychology in Daily Life")

Retention. — We must not think of the mind as a storehouse of experiences such as images, ideas, thoughts, feelings or acts; nor may we regard the brain as a file of negatives, any one of which may be printed from at will; yet something is retained in enormous quantities and is available for reproduction or reconstruction of our former experience.

What is the nature of this "trace" that is retained? Retention is entirely a matter of association, as already discussed both from the psychological and physiological points of view. From the physiological point of view we call retention a *neural disposition*.

"One's native retentiveness is perhaps unchangeable. It will now appear clear that all improvement of the memory lies in the line of elaborating the associates of each of the several things to be remembered. No amount of culture would seem capable of modifying a man's general retentiveness. This is a physiological quality, given once for all with his organization, and which he can never hope to change. It differs no doubt in disease and health; and it is a fact of observation that it is better in fresh and vigorous hours than when we are fagged or ill. We may say, then, that a man's native tenacity will fluctuate somewhat with his hygiene, and that whatever amount of intellectual exercise is bracing to the general tone and nutrition of the brain will also be profitable to the general retentiveness. But more than this we cannot say; and this, it is obvious, is far less than most people believe. When schoolboys improve by practice in ease of learning by heart, the improvement will, I am sure, be always found to reside in the mode of study of the particular piece (due to the greater interest, the greater suggestiveness, the generic similarity with other pieces, the more sustained atten-

tion, etc., etc.), and not at all to any enhancement of the brute retentive power." (James)

"The controversy started by this statement of James a generation ago has not yet died down. His statement means that each of us is born with a set brain capacity which cannot be improved by training. And he was right in the same sense that we can say that a farmer buys a certain kind of soil; it may be the richest alluvial soil or it may be the sand of the desert. Suitable cultivation may do wonders with a given soil, but aside from temporary fertilizing, skill in adapting vegetation to the resources of the soil, and the supply of its needs, the original capacity of the soil remains fairly constant in its class. But the superficial critic has said for thirty years: 'Behold the fact of phenomenal improvement in retentiveness.'

"The explanation lies in the fact that nature is prolific. Every normal person is born with a brain capacity for memory far beyond what is ever developed. Indeed, it is safe to say that any normal child or adult beyond middle age, may increase his memory by proper training at least tenfold, and often much more, and still not utilize his capacity to the limit. Such improvement in the use of a given brain capacity is no evidence of improving the capacity; it is nothing but evidence of acquired ability to use the available instrument or capacity.

"In judging memory we must not confuse native capacity and specialized skill. Most of our exhibitions of unusual memory are specialized skills. Pillsbury, the chess player, blindfolded, played simultaneously fourteen games of chess, two games of whist, and two games of checkers, and carried on a running conversation, while usually winning the games. It seemed to be easy for him and gave witnesses a feeling of uncanny weirdness; yet Pillsbury had only an ordinary memory in other respects. He had used his inborn capacity

to most excellent advantage by developing a specific skill for which he had natural aptitude and in which he displayed indefatigable patience. Memory is not a single faculty or capacity; it is several capacities, each with definite aspects, and may be developed into countless varieties of ability and skill." (The author's "Psychology of Musical Talent")

Reproduction. — Just as in sensory experience only a few of the infinite number of impressions reach the level of consciousness, so in memory only an infinitesimally small part of the available traces are reproduced in consciousness. Those that reach this level are recognized as conscious memories. A vastly larger number of traces are reproduced at the level of the subconscious, modifying all forms of cognition, feeling, and action. Indeed the most vital, the most serviceable traces appear in the more or less complete automatism, as in our normal, easy, graceful, skilful action.

Recognition. — Organic memory consists of only the first three stages — impression, retention, reproduction. It culminates in its reproduction in action or in the unconscious modification of mental content. Organic memories are of two types, — the instinctive, which are the organic race memories, and the habitual, which issue from the associations acquired in the lifetime of an individual. These two forms of memory we have considered, in part, in two preceding chapters. Conscious memory inheres essentially in the fourth stage, recognition. To remember an event in this sense of recognition, four things are essential. There must be (1) awareness of the event, (2) awareness of self, (3) conscious location of the event in time and space, and (4) belief.

The memory of an event may have the appearance of being instantaneous and yet may imply a rich interplay of conflicting processes. (1) The event may appear in word imagery denoting the scene heard, seen, or spoken, or the written name of the event. This, however, soon gives way to images of the thing or event itself or some mode of symbolizing it. This imagery usually comes first in the dominant sense and is accompanied or followed by associated images through other senses. There is rivalry between this image of the actual event and intruding images of associated facts for a focal place in consciousness. (2) All this imagery arouses reactions, particularly a rich play of reflexes, momentary glimpses of yourself through sensation, feeling and impulses which result in a feeling of "this is mine." (3) The original setting plays up in successive details as to representation of time and place in such a way as to make you aware of the location of this event in time and place while representing yourself as acting at that time and in that place. (4) You may experience uncertainty and hesitation. Your correct first impressions penetrate deeply and supply missing features. All this done, there gradually grows on you a certain degree of belief in the fidelity of the experience.

EXERCISE. — *Write an introspective account describing fully the character of your mental processes for each of the above four stages in your present recall of the laws of recognition from the last chapter. Do not look it up, but depend entirely on memory.*

THE EXPERIMENTAL STUDY OF MEMORY

The memory processes lend themselves readily to experimental investigation, both qualitative and quanti-

tative. Reports on such experiments fill many volumes in the technical literature from the points of view of pure psychology, abnormal psychology, comparative psychology, social psychology, psychoanalysis, physiological and brain psychology, education, industry, art, and anthropology. In each of these fields memory presents numerous problems for experiment and these have been attacked by diverse methods. In general they may be grouped under two topics, the learning process and disturbances of memory.

Methods of experiment. — Among the methods employed are the following: (1) By the method of controlled introspection, such facts as types of images, the rôle of images, the transformation of the image in recall, the control of images, the rôle of kinesthetic sensation, the character of associative bonds, and the feeling of belief in recognition have been investigated. (2) The method of recognition in objective measurement is used in much exact work: for example, a list of ten words is shown for ten seconds and then another list is shown containing some of the same words and the observer is required to identify those that are the same. (3) In the method of reproduction the observer is required to reproduce the remembered material as in writing, speech, or other form of action. (4) The method of conditioned reflex, now the principal method in behaviorism, registers memory entirely in terms of action involving reflexes. (5) Brain surgery and experimental physiology in the localization of functions of the brain bring remarkable opportunities for the analysis of memory functions by showing that under certain conditions disturbances at a

specific point in the brain produce corresponding disturbances of memory. (6) By the method of psychoanalysis, systematic analysis of the structure and function of latent memory, insight is given into the memory of processes below the level of consciousness, particularly in cases involving mental disturbances due to suppressed memories. (7) The methods of abnormal psychology, as in hypnosis and other trance states or in alterations of personality, have been particularly fruitful in the experimental analysis of subconscious memory.

Experimental problems. — The first rule in experimental procedure is to vary one condition at a time under control and keep all other factors constant, as nearly as possible. By the methods named, such factors as the following have been isolated and controlled in reasonable detail: the evolution of memory from its first emergence in unicellular animals to the highest; the development of memory in infancy through maturity and its decline in senility; the establishment of memory types; the measurement of individual differences; the reliability and unreliability of memory under certain conditions of action, report, or testimony; the strengthening of memory through stimulation, suggestion, and countless artifices and devices of training; the lowering of memory through depressors, such as high altitude and fatigue; the course of dissociation of memory in certain mental diseases, particularly in the amnesias; the analysis of memory genius; the development of extraordinary memory power and skill through mnemonic systems, intensified effort, and a persistent training.

Necessity of first-hand experiment. — The present and the three preceding chapters have been written in the light of, and as an informal embodiment of, the findings in such experimental procedure. It is impossible here to take up the matter in technical detail. However, for any serviceable understanding and appreciation of the nature and significance of experiment in this subject it is essential that you should perform some experiments under original control. The modern instructor in psychology has an abundance of such at hand. What the experiment shall be depends upon the equipment and local interests.[1]

The significance of individual differences. — Modern insight into the nature, types, and enormous magnitude of individual differences in memory places responsibility and furnishes aid in the selection and guidance of personnel for all sorts of occupations in which specific facts of memory are a condition of success. The time is passing for the selection of personnel without regard for native fitness for the occupation and no one should be more interested in such an inventory than the young person who is about to enter a trade, an art, a profession, or any other occupation in which some form of memory is an essential asset.

Transfer of training. — If you learn to perform an act of skill with one hand, does any of the acquired ability transfer to the other hand? Will thorough training in

[1] For the measurement of immediate memory for geometrical forms see the author's *Elementary Experiments in Psychology;* and for comparison of that with measurement of immediate memory for tones as systematized on the phonograph record see his *Psychology of Musical Talent*, Chap. XII. These two class experiments will furnish valuable insight into methods of control and interpretation in the memory experiment with material readily available.

Latin make you a better student in mathematics? Are there certain forms of learning that may be accepted as discipline for all learning? In what sense can we have transfer of training? These problems have been illuminated by experiment in recent years only to raise many related questions.

Present opinion may perhaps be best summarized in the vote of eight of the leading American Psychologists upon the following propositions:

I. Transfer of training is an established fact, and may be positive, negative, or zero.

II. The true amount of transfer from one field to another has not yet been found by experiment on account of one or more of the following handicaps:

(*a*) The maturity or previous training of the subjects tested.
(*b*) The absence from the training of the factors most favorable to transfer.
(*c*) The inadequacy of the tests to measure the traits sought.

III. It is a reasonable inference that a substantial amount of transfer to some related field would be found by an adequate test, if in teaching children, emphasis were placed upon the trait which the selected subject was more capable of developing, and if the factors controlling transfer were present in the training.

IV. Even if no great amount of transfer of training to any one field should ever be found by experiment, it would still be true that if small amounts of transfer of a valuable trait extended to a large number of fields, the

sum total of all these small amounts would be a very valuable educational asset.

V. Negative transfer or interference may take place when in the training of a certain trait auxiliary habits are cultivated which have to be broken down before the trait can function in a new situation.

VI. Zero transfer may occur when the habits tending to interfere and those tending to transfer just offset each other.

VII. There are elements of situations so fundamental in their nature that they occur again and again in connection with almost anything else. Special training with these elements has general value.

The vote stood as follows:

Statement	I	II*a*	II*b*	II*c*	III	IV	V	VI	VII
Per cent approved	89	56	78	67	67	67	89	89	89

CHAPTER XIX

IMAGINATION AND PLAY

Imagination

Our discussion of this topic may now be made very brief, because memory and imagination are so closely related that an account of one process covers the account of the other, particularly as regards the fundamental concepts of mental images, association, reflexes, instinct, and neural theory, which are in principle analogous in the two processes. Likewise, later chapters throw light on imagination as they do on memory.

Imagination and memory. — Memory represents the past, the old, the fact; imagination points to the fictitious, the new, the future. To the extent that a mental picture of the past object, situation, or event conveys the impression that it represents an actual fact, whether truly or falsely, it is a memory. To the extent that it carries the conviction that something new has been created in the present mental act, it is imagination. The distinction between memory and imagination is therefore not primarily that of "faithfulness to fact" but rather one of belief or conviction. There is a gradual transition from organic memory as "faithful reproduction," through all degrees of fidelity in "production," up to pure imagination as a creation of something new.

Our common experiences of memory and imagination lie between these two extremes and are blends of reproduction and production.

The formulation of a theory, the molding of a figure, the writing of an epic, the planning of next year's vacation, are all acts of imagination; but the success of each depends upon faithfulness to facts; that is to say, imagination in the large bulk is representation and requires the highest kind of fidelity to facts. It is the newness of the design, the newness of the arrangement or the ideal that makes it imagination. But the new creation always rests upon a discriminating memory.

Imagination is therefore defined as the process of forming new ideal combinations, which depends on relative absence of objective restriction and considerable freedom of subjective selection.

Passive and active imagination. — There is a gradual transition from the most spontaneous, fanciful, fantastic, and unrestricted imagination which we call fantasy up to the most rigorous, logical, and labored creative imagination. The one extreme is passive, the other active; but one gradually blends into the other. Inspiration, for example, in all its various aspects, usually denotes a spontaneous outburst; but it comes only to those who have labored hard in paving the way. This is the testimony of all great artists and inventors. On the other hand, fantasy is the untrained and unrestrained imagination which represents lassitude and irresponsibility.

Yet imagination calls for a sort of abandon. The

play of the child and youth makes possible a larger life than the dull activities afford only to the extent that the player loses himself or, as we should say, finds himself in the realism of the play attitude. The exercise of curiosity in this play attitude gradually develops into free self-expression for the pleasure of self-expression and self-extension in the attitude of investigation, invention, and creative art. But imagination also plays the humbler rôles in vivid perception, lifelike memory, rich feeling, meaningful thought and action. It is imagination that furnishes the color and glow.

Imagination types. — The *sensuous* type is characterized by luxuriant and realistic imagery in terms of which experience is created and re-created. Instead of recalling experience in a matter-of-fact way, one endowed with this imagination at once reconstructs experience in images more or less fantastic, conventionalized, idealized, and enriched, and often so molded as to embody his feelings, biases, and aspirations or fears. He lives in a world of the senses and enjoys a sort of abandon and luxurious freedom from restrictions of the commonplace. It is the life of the impressionist, an effervescent life of the moment, reverberant in sensations and images.

The *intellectual* type is ordinarily spoken of as the scientific or philosophical imagination. Creation takes the form of propositions, theories, postulates, and logical ideas more or less concretely and directly represented in images. The sensory and imaginal elements are relatively in abeyance and the process is cool and deliberate. For the reason that it deals consistently with large

units of thought, this is the master form of imagination; the feeling involved is placid but may be intense.

The *sentimental* imagination, often called the artistic, is characterized by its tendency to idealize experience in terms of the higher sentiments. Objects and events assume meaning with reference to remote ideals, or sanctions, such as harmony, unity, pleasure, or the opposites of these. The world is a world of truth, goodness, and beauty, or their opposites, rather than the humdrum of the common man's experience; experience is thought of in terms of ideals and feelings rather than of events and things.

The *impulsive* imagination is that which results in display of feeling and the arousal of the emotion in others. It lacks logic, poise in sentiment, and continuity of effort. It often results in great creations, as it taps the deeper resources of life under the stimulus of great emotion; but it tends to be sporadic and is wanting in cogency and continuity.

The *motor* type of imagination, sometimes called the practical or mechanical imagination, lacks the appearance of mental creation and often suggests the effort of the plodder. It appears in the person whose interests are practical and who can foresee only as he gradually works out situations by doing. It is characterized by persistence in effort, serviceable forethought, and the tendency to achieve practical success.

To these may be added the *balanced imagination* — that which includes each and all of the type-traits in well-developed symmetry. For further detail of description we may designate various combinations, such

as impressional-sentimental; the relative strength may be designated throughout by such adjectives as weak, moderate, and strong.

Play

Play is free self-expression for the pleasure of expression; or, as Ruskin puts it, "an exertion of body or mind made to please ourselves, and with no determined end." The introduction of the natural history method in psychology has transformed the conception of play — its nature, its function, its evolution, and its meaning; and, with the deeper significance discovered in the projection of our imagination into play, comes a broader interpretation of education, knowledge, industry, morality, art, and religion.[1]

Imagination, as we have seen, enters into all levels of normal mental life, but finds its free outlet in play as distinguished from work or task. To throw some light on the function of imagination, we shall trace briefly in this chapter the nature and rôle of play in daily life of child as well as adult.

A preparation for life in childhood. — What is the child doing? He is exercising curiosity in overcoming difficulty. That is the law of growth. The senses and muscles develop through play. Touching, groping, and grasping; rattling, babbling, and shouting; visually pursuing, inspecting, and analyzing; tasting, sucking, and smelling; pulling and pushing, and countless other sensory impressions with appropriate responses and the production of stimuli for these grow gradually out of semi-

[1] Abridged from author's *Psychology in Daily Life*.

random movements and simple reflexes and are progressively transformed into higher forms of imagination and skill. Through such exercise of curiosity, the control of the senses and the muscles is progressively adapted, resulting in precision, enlargement of meaning, and mastery of response not only for these situations but in general control of body and mind.

The child begins his training in the use of tools and acquisition of mastery, both mental and physical, by dropping playthings and throwing things helter skelter and thus gets his first practice in the skill later required for projecting himself by a blow or a throw and reciprocal movement of catching and parrying, as in all forms of ball games. He learns to project his personality through the senses and muscles as they are progressively coördinated. When he later leads the dog, the kite, or his own playmate, he is pursuing the pleasure of being a cause and is extending his own personality through a progressive mastery of his mental and physical organism.

The higher mental powers are normally developed in close connection with the use of the senses and the muscles, for the child throws his whole being into play. He is ever responsive and play is the main avenue for the free outpouring of his various selves in action. His memory, his reasoning, his feelings, emotions, and sentiments grow and are strengthened and refined and made serviceable through play. The free and whole-hearted expression of his instincts through play transforms and fashions them in reaction to the environment, thus building character. The social attitude and æsthetic

nature of the child are peculiarly dependent upon play for their normal growth, for the child at play reproduces, on each successive level of his development, the industrial, social, moral, and intellectual and artistic life of the adult.

There is a gradual transition from the child's racket and howl to the appreciation and grasp of music in the adult. The analytic instinct of curiosity which moves the child to tear things apart and examine them is a part of the making of the scientific experimenter, the artist, and the philosopher. The collecting instinct which fills the urchin's pockets with pebbles and bugs later fills our storehouses, museums, art galleries, theaters, and churches.

Warfare and love, fiendish fight and self-sacrifice, obedience and defiance, the comic and the tragic, regeneration and degeneration, domestic occupation and the spirit of venture — in all these the child lives at his own level, and gradually approaches the stern adult realities, taught and trained, hardened and softened, warmed and cooled, roused and rationalized, through these very engagements in play, which without break or loss of their original character gradually blend into the duties, responsibilities, opportunities, and achievements of adult life.

Thus the body develops more through the exercise of play than through work. Sensory experience gradually acquires associations and responses, comes under control of voluntary attention, and becomes differentiated and serviceable through play; memory, imagination, conception, judgment, and reasoning are whetted, strength-

ened, and enriched through their exercise in play; the effective life becomes sensitive, adapted, balanced, and serviceable through play; habits are formed, instincts developed, impulses trained and brought under control, streams of subconscious activities crystallized, and the power of attention disciplined through play. In short, play is the principal instrument of growth. It is safe to conclude that, without play, there would be no normal adult cognitive life; without play, no healthful development of affective life; without play no full development of the power of the will.

This view does not deny the value of work in the form of drudgery, routine task, and rigid discipline as a means of development, a duty even a pleasure. It simply stresses the fact that, all in all, play holds the larger sway.

Nature has made the period of infancy and childhood long in order that the fruits of child play might be correspondingly great. It is well for the adult director of the child's activities to realize the largeness of the task of the child; to realize that normal life may be crushed by depriving youth of the rights and opportunities of play; to realize the necessity of encouragement in defeat, of applause in victory, of approval in success, and to exercise sympathetic and prudent selection in shaping the native childish impulses for the making of the man through play.

Continuous throughout normal life. — Free stimulation of the senses is often a means of play. Normal adults play with sweetmeats, sunlight, odors, colors, forms, temperatures, strains, and even pain. Reminiscence is one of the charms of life. The effective novel-

ist lives his characters. It is the play illusion that makes poetry. The theater is by nature as well as by name a playhouse. Idlings, romance, and invention, as creations of fancy, are play. A score of men engage in action on a football field, while thousands replay the game on the bleachers. Wit and humor, mental contests, even when they occur as a part of work, exhibit the aspect of play. The musician "plays" frequently as a form of free self-expression for the pleasure of expression. Even misery, tragedy, misanthropy, as well as triumphant victory and applause, are exhibitions of this free self-expression. Sport is scientific play; witness hunting, racing, flying, and gambling. The best recreations carry the mark of sport and serve the purpose of human development. Dancing and all social games weave a tie that binds the social body into one. Fishing, skating, riding, and golf exercise parts of the mind and body that have not been exercised in labor. Witnessing amusements and games enables us to live in images the more strenuous realities of diversified action.

Adult play. — Sport holds its sway only so long as there is room for advancing achievement; one sport follows another in answer to the needs of maturing man. Plays, like serious occupations and the associations of life, change with the growth of the individual. Recreation, to be effective, must possess an engaging charm in the form of fresh impressions, novel associations, and new outlets for activity. Even rest serves its purpose only in so far as its form is progressively adapted to the changing needs of the constitution. There are visions to be seen, inspirations to be received, ideals to be set

aglow, sympathies to be cultivated, emotions to be refined, dreams of achievements to be enjoyed, riddles of life to be solved by the proof of experience. While adult man pursues these objects through systematic efforts and tasks, much of his learning and adaptation for the larger life comes through the exercise of the play impulse and through living in the play attitude. The man or the woman who has ceased to play is intellectually dead.

In all favorable occupations much that goes by the name of work is done in the spirit of play; and, conversely, much that goes by the name of play is downright drudgery. Witness many of the "social duties" which have the appearance of play but are often done as painful tasks. The greater part of life is neither wholly play nor wholly work. The scientific study of play will substitute a large number of specific terms for the vague term "play," as has been done in the case of the term "memory." There need, therefore, be no dispute in the future as to what is work and what is play, for discussion will center upon the analysis, description, and explanation of specific instincts, impulses, associations, attitudes, and actions characteristic of play, regardless of whether they occur in play or in other activity.

Primitive man lived relatively free from thoughtful care; the child, though endowed with a keen imagination, is disposed to tread in the footsteps of his distant ancestors. Civilization has modified this tendency in two ways: it has established a sense of responsibility, a prudent forethought in the division of labor, and a sympathetic effort to make advancement; on the other hand,

it has opened up vast avenues of possibilities, not only for playful expression in industry, art, science, education, and religion, but also in the increase of means and avenues for pure play. While primitive man was essentially a playing animal, cultured man has vastly more play interests than had his remote ancestor. Indeed, play goes with greatness and with a strenuous life. To Mr. Roosevelt the wilds of Africa and the courts of Europe formed a continuous, fascinating playground in which he played with all his heart, and all his surroundings played their gayest for him while the world proclaimed him a leader in political thought and action.

Play as self-realization. — A most vital element in the feeling of self-realization is the experience of growth. Men, like trees, die when they cease to grow. We must limit ourselves to bare mention of some of the most significant traits of play in its normal function in this free self-expression.

Play preserves the racial inheritance. As we have seen, man has the instinct to do everything that he can do; and the possession of capacity carries with it the tendency to use that capacity. Work and other necessities of daily life develop a relatively small part of our instinctive resources. Groups of instinctive capacities would be lost were it not for the liberal education of play; for play develops those traits which have not been drawn out by the spur of necessity. It elevates even as it levels. Cultured life is artificial, narrow, specialized, and intensive; and this is indeed a condition for great achievement. But play develops the possible man, rather than the man of choice or condition. Thus play

conserves through use the inheritance from millions of years of growth.

Play represents a reversion to type. The tendency in play is to fall back upon the elemental. Whatever artifices of war may be devised, fighting plays will always gravitate back toward the simple form of direct bodily contact, be it with fellow-men, beasts, or the forces of nature. It has been suggested that boys climb trees and swim in response to survivals of these specific activities traceable to distant arboreal or aquatic ancestry. This assumption is unnecessary, for boys come into this world with limbs fitted for climbing and swimming; trees are common and inviting for climbing, and the water is a great "temptation" to the boy. The tree and the water challenge curiosity, bravery, and excitement. In this manner the whole boy, the whole man, naturally gravitates toward self-expression in elemental forms of behavior.

Play engenders a sense of freedom. Witness in play the freedom in movement, imagination, and joy; and, in the free desire for mastery, freedom is the goal. With power as with duty, in a great civilization come restriction and strain to millionaire, ruler, or servant. He therefore turns to diversion in play for freedom for the expression of his heart cravings. Whether in speculation, sport, art, invention, adventure, social contact, recreation, or rest, the sense of freedom which play generates is an alluring charm.

Play fascinates. It attracts, engages, and holds the individual in a state tending toward elation. This tendency, when it is real play and not mere social labor or

conformity, carries the dancer away in so far as he falls into a state of diffused and dreamy consciousness, intoxicated by the sense of pleasure, lulled by the rhythmic movements, and soothed by the melodious and measured flow of music. This element of ardent fascination and elation may be seen in some degree in all play — in the romping of the infant, in the adolescent mating plays, in the sport and adventure of youth, in speculation and gambling, or the recreation of the adult. Indeed, in this fascination lies a grave danger — the danger of overindulgence.

The satisfaction in being a cause and extending personality is one of the compelling motives of play as well as one of its direct rewards. This is well illustrated in games of competition. In so far as achievement expresses and reflects our freest ambition, fancy, or ideals, it is rated as part of ourselves, of our cherished personalities, and is attributed to self-exertion.

Play generates a sense of fellowship. Laying aside petty differences, interests, and points of vantage, the playing group fuses into a common consciousness on a plane of equality, with common means, common interests, and common pleasures. Play is, therefore, the making of the social man. We become like those with whom we play. A deep feeling of fellowship is one of the greatest human rewards. Referring to the enemy nation in the Great War, an Englishman said: "We shall be glad to work with them, but we cannot play with them."

Play is satisfying because it is positive, even aggressive. It stands for acquisition, seriousness, and optimism, as may be observed in child or adult that has a "playful

heart " as opposed to the one who disdains play. The feeble-minded play comparatively little. Thus play is an expression of the joy of life, not so much in deliberate, systematic play, as in the entry of the play attitude into work, or its reflection in nature, truth, and other stern realities. Indeed, everything in life presents aspects of play to the eyes of the mentally alert. The play attitude is the most universal medium for the manifestation of the sense of freedom and conviction of the worth of life when these exist.

Play is serious and whole-hearted exertion. When we work we walk or plod; when we play we skip or run. When performing a duty we do as much as is required; but when we play we do all we can. If the football players worked as hard at their mental tasks as on the football field, there would be fewer failures in the class-room. There is a charm in extreme exertion.

The seriousness of play is one of its fascinations. If we join in a game and are not serious or zealous about it, we are not playing. Play means to be in the game. It is engrossing absorption that drives dull care away.

Play rests upon make-believe. Liberated from realities, it accepts the ideal and lives it as reality. Each game has its distinctive charm. There is the attraction of variety in the free choice of games. It changes from day to day, from season to season, and in a progressive order from one game to another. The moments of supreme satisfaction, the moments of highest realization and appreciation of life, come from activities which are most conspicuously characterized by play attitudes — either from play pure and simple, or from work in which

play-motives dominate. We all have our work, our set tasks and duties; but those of us who get the most out of life are they whose work would be their preferred play, quite apart from its pursuit as a means of livelihood. Conversely, the truest and most fortunate are those who obtain their relaxation, rest, recreation, stimulation, and self-expression without making tasks of them. The things we do for the pleasure of doing are the rewards of life; they are an expression of the freed self, the channels of release from the routine of necessity, the sources of inspiration, power, and satisfaction.

This digression from the more systematic treatment of our topic may be justified, in that it aims to show that acquaintance with play contributes much to the systematic survey of the facts of mind in our daily activities; it adds to the general hold upon life in power of interpretation which is a part of culture; it indicates at least the general direction in which efficiency, through the control of natural sources, lies; it adds to the appreciation of the origin, the complexity, and the beauty of human resources and values.

CHAPTER XX

THOUGHT

Having considered the stages of presentation and representation in the knowing processes we now come to the third and highest level, namely, elaboration or thinking. It is customary to describe this process under three general headings: conception, judgment, and reasoning.

Conception

Exercise. — *Observing the mental processes involved, write a definition of "hat." Work at it faithfully for a long time until you are satisfied that the definition is reasonably adequate. Test the definition by observing if it covers all hats and includes nothing but hats.*

Formulating a concept. In writing this definition you have formulated a concept. The task proved far more difficult than you had anticipated. It left you with a lot of uncertainties. In attempting to distinguish a hat from all other things and to make your concept include all hats, you found trouble with shape, material, purpose, use, etc. It was even difficult to exclude such things as nightcap, parasol, and kerchief. These difficulties appeared because you were forced to think. The person who does not think often rests in comfortable assurance that he knows, for example, what a hat is. To some extent, your uncertainties were proportional to the seriousness of your thinking. It is in the wrangling with these uncertainties that we clarify our concepts and thus

arrive at a truer realization of the actual situation, the truth.

Let us now go back over this experience and see what happens when we try to clarify a concept for definition. No two persons have the same experience but the following is perhaps typical:

1. *Assembling of data.* — The word "hat" probably first flashed into your mind in visual, auditory, and kinæsthetic imagery. But, whether the word-image came first or not, there instantly appeared in imagery a veritable millinery show of hats — not only hats but wearers of hats, persons in different seasons, different climates, different tastes, rich and poor, men and women, young and old. Even images of such associated features as money, admirers, or sunshine gained recognition. You had a vague awareness of reaction to each of these images, particularly in consciousness of likes and dislikes. All this happened in so short a time that perhaps you did not notice it at all. Your consciousness at the moment was perhaps like a snapshot view of a horse-show or a fair. The impressions may not have lasted more than a fraction of a second each; yet they were impressions of great richness and lightning speed of action. This display resulted in a confusion; and, as if to get a fresh start, you possibly went back to the image of the word hat again and reminded yourself that your task was to define.

2. *Abstraction.* — On the basis of this first impression, certain fragments of description presented themselves; for example, to keep the head warm, to keep the head cool, an ornament, a headgear, a cup-shaped object. But instantly you noticed that some of these terms would

not do because they included too much or too little. You therefore proceeded to discard and abstract the irrelevant with the result that you were left with a residue of available material for the definition.

3. *Generalization.* — You probably first adopted a generic designation such as "an article of wearing apparel for the head" and then proceeded to assemble specific differences, those characteristics of hat which seemed to be true of all hats and yet differentiated it from non-hat. This series of specific differentiæ served to limit the generic designation and give it specific content. The results you embodied in a sentence which is the definition and constitutes the description of the concept.

4. *Naming.* — The process of forming such a concept took you back over your entire life experience. The concept may be said to represent all that has been in your mind in the way of perceptions, memories, and actions about hats. All these experiences were recognized in such a way as to form a unit — the concept. But this process would be a poor tool of thinking. Human beings have, therefore, acquired the ability of labeling concepts to avoid the necessity of reviewing the entire experience each time. The label in this case was the word "hat."

Growth of a concept. — The first time that a child sees a book it may mean nothing to him or it may mean something to eat, or something to toss or tear. He may see the book but he does not know what a book is. This has to be learned gradually by acquiring meaning in perception. Now, if we make a violent assumption that a child sees and uses repeatedly one book and acquires a serviceable meaning of what it is but does not know that other

books exist and cannot invent any, then his perception, his memory, and concept of "book" have the same content. But as experience broadens he finds books with pictures and no print, print and no pictures, print and no cover, cover and no print, books of all kinds of subjects, books of all sizes, and styles. For each new experience his concept of the class "book" grows. Thus by the time he is grown up, the class name book may represent to him thousands of particular experiences with books. Yet throughout life he finds difficulty in distinguishing book from notebook as to possible form, content, purpose, and similar features. Is a magazine a book? Is a paged calendar a book? What is book-making in the races? To meet this growing difficulty he carries on a continuous process of rejection and selection of traits of book, reaching into minute ramifications of detail in precision. He rejects the non-essential and selects and generalizes the essentials. This double process becomes very complicated for, with each restriction of this kind, he whets his power of observation and discrimination into more and more technical alertness in the recognition of detail, as in the labors of the bibliophile, the literary critic, or the bookmaker.

Thus the concept is never closed but is a perennial growth throughout the plastic life. The child's curiosity becomes the scientist's passion for systematic inquiry and the artist's inspiration for creative achievement. Meaning is progressively woven into the concept. The child's first inquiry is "What is this?" "What is the name?" The name satisfies him. Names for concepts give satisfaction. The name remains constant

but the meaning changes. The child's name "book" and the bibliophile's name "book" are formally identical and similarly satisfying; but the one represents limited, crude experience whereas the other represents knowledge gained from a wealth of first-hand critical experience.

The name, however inadequate in itself, is a vital step in conception because it serves as a label, tag, or pigeonhole for the vast mass of collected material any part of which may be found, recalled, and identified from this cue. Each differentiating concept demands a name — pamphlet, quarto, monograph. Concepts of a high order would be impossible without language. Language, therefore, becomes a means of making thought a social process. Our perceptions and images are personal experiences but, through the instrument of words, thinking can be shared and thoughts may be conveyed to others. The finer meanings, however, remain personal, consisting largely in the attitudes, impulses, or organic reactions which the associations radiate from the name.

For the normal alert individual no concept is completed or closed during lifetime. Each day may bring new possibilities. This is what we mean by education, culture, and broadening of experience. Even such concepts as "hat," "apple," "chair," and "house" are subject to growth by the revelation of new phases in the progress of experience. The old fogy, the biased person, and the idiot, are characterized by the fact that their concepts are relatively fixed. They are not open to new meanings. On the other hand, the uneducated and unintelligent are characterized by loose or inadequate con-

cepts. They not only cannot define ideas, but they do not experience correct or adequate ideas.

As we found with the percept, so with the concept; it is what you are. Art and nature, practical affairs and events have their true meaning to the individual in terms of what he is — his interests and reactions.

Traits of inadequate concepts. — The correctness of this analysis may be shown by pointing out that the principal sources of error in thinking, in so far as they lodge in the concept, may be grouped about these critical stages: (1) The adequacy of meaning in the concept depends upon the number of relevant associations it has formed. Meaning and thought for a given individual are measured mainly in terms of a variety of accurate first-hand observations. This is well illustrated in natural history. The concept fungus varies in adequacy with the extent of the naturalist's acquaintance with all the possible varieties of fungi. Even in cold science real thinking must be accomplished through personal means. It cannot be done by borrowed concepts, or mere words. Many persons are keen objective-minded observers but suffer from faithless memory which deprives the concept of meanings once possessed. (2) The act of thought consists essentially in abstraction and generalization. Many persons are keen observers and remember well but lack that power of attention to the abstract which is necessary for the systematic rejection of the non-essential and selection of the essential in "consecutive thinking." Herein lies essentially the difference between common sense information, which is unorganized, and scientific knowledge, which is organized. (3) The vast mass of our knowledge

is mere formal, verbal, borrowed concepts. These are of great value and are necessary in the interests of economy. They constitute the stock of our information but they are not tools for thinking; for the genuine thinking takes place in meanings, not words or even images. Elaboration in terms of borrowed concepts is indeed common but it has merely the appearance of thought. It makes but little progress. (4) Finally, concepts suffer from inadequate language. If the label is wrong, the goods might not be identified or may be missent. The word idea, for example, is used correctly in at least nine radically different meanings. The use of such a word in psychology is like sending an express package with nine different addresses on it.

Experience of a concept.

EXERCISE.—*In thinking of the concept "book" observe in repeated and concentrated trials the images that represent it. Write a brief, specific account of the character of this imagery.*

Psychologically there is no new mental unit in the concept beyond what we have found in perception, memory, and imagination. The experience of a concept is entirely in terms of images, associations, and actions. It has often been maintained that the thing present in consciousness is a generic image, analogous to a composite photograph. Experience shows that such an image lacks the stability of a composite picture and looms up in individual features. What we really find, as in the introspection of the concept "book," is image groups flashing in kaleidoscopic fashion from feature to feature like the scene on the moving picture screen accelerated in motion. When I think of "book" it is as if every feature of book

I had ever known rushed and clamored for recognition. Just as in a real objective situation of such a rush, attention fastens upon one image or object at a time in focal consciousness with others nearly focal and an increasing massive impression of the surge of images in the background. The first noticed and the most stable are usually those containing the commonest or most familiar traits, but any of the laws of association may operate to force recognition of very specific, rare, or even freakish features. Thus, in my own experiment on the concept "book" a moment ago, the name Omar Khayyám, the appearance of a pocket edition, the image of a cynic and epicure represented as the creator of a type of literature, flashed in succession, ruthlessly crowding out the primary and more basic images of "book." A merely verbal image, the image of the word, frequently comes first and from this all the trains of images radiate. The images may come in any or all of the senses. They are not always noted as images; there is rather a feeling of direct consciousness of the object. The abstractness of the concept lies in the organized array or classification of images in reserve of which trait features gain recognition. Often the abstractness consists in the acceptance of the mere word image, in the selection of the one feature which has significance, or in giving the images only marginal consciousness.

Expression of the concept. — The vital meaning of a concept is represented in actual organic expression; to a large extent meaning is the reaction of the organism. Ordinarily this expression is the motor phase or sequel of the image. The meaning *cost* of a book appears in a

rich play of organic movements expressive of restriction; the meaning *beauty* in a book stands forth in a train of organic movements expressive of delight and well-being as well as in attitudes or inceptive tendencies of aggression; the meaning of *truth* of books swells the hierarchy of movements expressive of pleasure and repose. Large size, small size; purity, impurity of content; library, private book; the joy of reading, the boredom of a scene; science, poetry; — the countless meanings that may play a rôle in the vital concepts appear in impulsive movements, reflexes, instinctive and habitual attitudes and movements, and have characteristic effects on the internal secretions. Hence the meaningfulness of a concept may be judged by the way it acts. The behaviorist is even willing to limit the study of concepts to their expression in reflexes.

Flexibility of concepts. All definitions are descriptions of concepts; the formation of an adequate concept is a preliminary to the formulation of a definition. The definition is an amplification of the concept name. Ordinarily we think of definitions as being exact. Our analysis, however, makes it clear that exactness in most definitions is out of the question, for meanings vary with individuals, and for the same individual from time to time; "deep" meanings are rich and too far-reaching to be adequately represented in definition. Yet it is definition that makes science. Science is possible when we can reduce the personal element to a minimum by isolating the traits in the concept so that each may be repeated and described systematically. Even scientific concepts are limited to the serviceable, and often ignore

the deeper meanings. Consider, *e.g.*, a definition of hope, truth, infinity, love, or even gravitation.

Knowledge and the concept. — All knowledge takes the form of concepts — adequate or inadequate. We have concepts for all that we know, real or imaginary, objects, relations, actions, ideas, ideals, truths. The concept operates in perception representing the past experiences to which the present impression is to be referred; likewise in memory, imagination, and suggestion. The concept is the stabilizing and concrete element in experience. But it is particularly in the thought processes that we are dependent upon the concept as the concentrated unit of thought. The concept is the supreme embodiment of the principle of economy in that it represents units of unlimited masses of classified experiences. Truth for the individual, as for mankind, is a system of growth, — ever-changing, serviceable concepts, the embodiment of experience.

Judgment

To judge is to classify, or to refer a new situation to its appropriate concept. It is an interpretation of the facts in hand. There must be a new situation, two or more alternatives open, and the outcome in doubt. If the situation is not new there is nothing to judge; if there is no alternative there can be no doubt; if there is no doubt there can be no decision.

The judgment in ordinary thinking has essentially the traits of the judgment rendered in the procedure of the judgment on the bench:

"There are three such features: (1) a controversy, consisting of opposite claims regarding the same objec-

tive situation; (2) a process of defining and elaborating these claims and of sifting the facts adduced to support them; (3) a final decision, or sentence, closing the particular matter in dispute and also serving as a rule or principle for deciding future cases." (Dewey)

Stages in the judgment. — Let us dissect a judgment and observe how these traits are present though stated in slightly different terms and order. You open the door one winter morning and exclaim, "This is a blizzard!" This judgment was made quickly, almost instantaneously, yet upon close examination we find a number of complicated processes more or less expressed.

1. *Clearing the concept.* — There is first a clarifying of the concepts and percepts involved. "This" as perceived is resistance to the wind, chill, shiver, whiteness of snowflakes, darkening of the atmosphere, impact of the snow, drifting, swaying of trees, sighing of the wind, etc. "Blizzard" is a concept representing all your past experience and other knowledge of this phenomenon — cold, high wind, whistling, white flakes, darkening sky, drifting, suffering, various restrictions, etc. The first thing in the way of consciousness in this judgment was the impression of the present situation with the suggestion from stage to stage of a concept which may tally with this situation. The clarifying process consists in a rigid arrangement of facts observed and traits involved in the proposed concept with a growing feeling of satisfaction and conviction of the correctness of the possible classification.

2. *Abstraction.* — But in the meantime many alternatives are suggested. Thus arises doubt and the need of a critical review. This takes the form of abstraction or

elimination. One by one the possible rival alternatives are slipped off: it is not smoke; it is not the darkness of the evening; it is not rain; it is not hail; it is not a sand-storm. Thus you systematically clear the ground by reviewing upon critical evidence all the plausible alternatives that came to your mind as answering to a considerable number of elements in the situation.

3. *Generalization.*—The process of selection goes hand in hand with rejection, for with each elimination the issue becomes more sharp and clear. You are then in a position to specify, test, and define the issue: hard, white, cold, crystals of snow, whizzing through the air, darkening the atmosphere, and forming into drifts, high wind as indicated by the swaying of the trees, loud whining sounds, and strains upon my body, is a *blizzard.*

4. *Recognition of meaning.*—From the first a recognition of meaning has been gradually taking shape. The focus of consciousness on image after image or impression in the analyzed situation has permitted each of these to run its course in feeling, impulse, and organic reaction, thus developing a rich appreciation of what it all means. If, for example, the element of coldness were absent, many of the mental and physical reactions would be absent and "blizzard" would mean something different from what it now does. The judgment, therefore, results in the enrichment of the same sort of meaning that we found in the percept and the concept.

5. *The decision.*—The decision classifies. Tagging or naming of the conclusion is the judgment expressed in language. This also is a cumulative process from the very beginning, because every concept when first sug-

gested came as a name. Thus we say, "science begins with classification and science ends with classification."

Sources of error in judgments. — The process of judgment is usually long and elaborate in proportion to the difficulty to be overcome and the degree of reliability sought. It may, however, approach the instantaneous either because the problem is easy or because the judgment is superficial, inadequate, or incomplete. That such factors in the process as those just enumerated exist or should exist in even the quickest judgment is well illustrated if we attempt to locate the sources of error in judgment. Just as a study of illusions serves to bring out the factors in the perception of space, so the recognition of types of false judgments serves to make recognition of the stages in judgments clearer.

EXERCISE. — *Write two judgments of each kind representing lodgment of the error respectively in (1) inadequate perception, (2) false memory, (3) faulty elimination, (4) faulty generalization, (5) inadequate realization of meaning, and (6) ambiguity of language.*

"The process of judging is always simple, the results of the judgment are always to be found in a concept or a type, the direction of the judgment is always in terms of the momentary context or purpose. All forms of judgment are alike, too, in that their occasion is furnished by some stimulus. All begin in some stimulus and end in a meaning or concept. The concept alone is actually conscious. The meaning that is added may be a type of the simple kind that makes the object, it may be a statement of relative intensity between different parts of the total, or it may be an appreciation of the value of the presented with reference to some established standard. In any case it is the reception of a presented stimulus into the unified experience." (Pillsbury)

Conditions of judging. — The vast mass of our rational knowledge expressed in judgment is not the result of judging on the part of the possessor of the knowledge. It is ready-made judgments which are handed down. It is no discredit to have such but they are not ours and they will not mean what they should mean if they were ours. The average student wants ready-made judgments; the thinker wants to find out for himself. To exercise the power of judgment three things are essential: (1) the requisite materials, concepts that are your own; (2) the power of reflection or deliberation that has control over voluntary attention in precise analysis and synthesis; (3) the power of expression; that is, the ability to couch the decision in adequate language.

Kinds of judgment. — Logicians classify judgments in many ways. They may be positive or negative. "Mr. Jones is rich. Mr. Jones is not rich." With reference to directness they may be intuitive or deliberative. "$1 + 1 = 2$." "This is a beautiful day." "I am happy." These are intuitive judgments because they are immediate like perception. Knack, tact, cleverness, and discrimination show in fine intuitions. "Virtue brings its reward," is a deliberative judgment because it could have been arrived at first-hand only after much deliberation and weighing of evidences. With reference to the progress of the judgment it may be analytic or synthetic. "The tree has bark" is analytic because it simply fastens upon one of the ingredients of tree. "Poplar makes good paper pulp" is a synthetic judgment because it adds to our commonly accepted qualities of tree. With reference to belief, judgments may

be categorical or hypothetical. A categorical statement is a plain assertion. "This boy is dull" (simply categorical). "I have a soul" (existential). "He is either guilty or not guilty" (disjunctive). In the hypothetical judgment we stipulate the condition: "If I win I shall be happy."

Reasoning

The chief function of reasoning is to aid in the solving of new problems, whether concrete or abstract, and to carry knowledge beyond the bounds of perception, memory, and imagination, particularly in dealing with generalization from a mass of facts. The goal is always truth.

Reasoning in the restricted sense is a collection of judgments leading to a new judgment. It is a process of elaborating knowledge in hand in such a way as to draw new knowledge out of it. It is a solving of problems by foreseeing the end and weighing the means. It is purposive thinking of which the conclusions are capable of proof.

"Thinking in the best sense is that process which considers the basis and consequences of belief. . . . Reflective thought is active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds which support it and further conclusions to which it tends. . . . Thinking is that operation in which present facts suggest other facts in such a way as to induce belief in the latter upon the ground of warrant of the former." (Dewey)

The word "thinking" is used in a broad sense to cover the three processes, conception, judgment, and reason-

ing, and in a narrow sense as synonymous with reasoning only. As we shall see, there are many low forms of so-called thinking or reasoning. Psychologically, reasoning does not involve any new type of mental processes beyond those involved in conception and judgment. Indeed, reasoning is merely a judgment about judgments. The deepest interest in the reasoning process comes from the point of view of logic, which is the art of reasoning or right thinking; while the psychology of reasoning is concerned only with the nature of the mental processes involved. A brief reference to the logical aspects may be in order to show in what sort of setting the mental processes operate in reasoning.

Inductive reasoning. — Suppose that you are called upon to make a pronouncement upon the moot question, "Is the world getting better?" You will then in more or less attenuated form pass through stages like these:

(1) *The assembling of judgments.* — You will think of the large number of cases in each of which you can say that the world is getting better; as in the status of women, the treatment of prisoners, the prevention and cure of disease, etc. With them will come a large number of cases in which you get corresponding negative judgments. You select and seize upon specific elements of the concept "world," and the concept "better," and the concept "not better." This array of judgments represents your resources in sagacity, versatility, personal meanings.

(2) *Striking a balance.* — You then cast up the evidence for and against, taking into account not only the

number on each side, but also the weight and kind of value in each. For this reason the final decision, yes or no, expresses only a formal though true reply by indicating the direction in the balance of evidence. The consciousness of meanings gained in this process of weighing evidence is vastly richer than anything that can be expressed in a verbal decision. This difference between the real and the formal result of reasoning is expressive of the difference in value of first-hand reasoned truths, and mere formal labels of truth.

(3) *Conclusion.* — The conclusion which is thus cumulative may be accepted at any stage in the process of weighing, depending upon the persistence of the inquirer, the degree of certainty needed, and the depth of insight desired. The conclusion is always tentative and incomplete, but it furnishes the most vital type of the serviceable realization of meanings in truth. This type of reasoning is called inductive, because it consists in the assembling of evidence.

Deductive reasoning. — In deductive reasoning we establish the truth of a particular conclusion on the ground of a universally accepted general conclusion. The classic example takes this form: All men are mortal; Socrates was a man; therefore, Socrates was mortal. Here the first proposition is said to be universal because in all history of observation no exception has been found. If that is true, and the second proposition is true, then the third proposition follows from the other two and must be true.

The principle of deduction is of the most practical and far-reaching importance. In daily routine we accept

universals on authority, custom, or reason, and continually use them. Accept the principle of gravitation and you know immediately that millions of kinds of things will fall of their own weight. Accept the principle of truth telling or justice or honesty, and your daily acts will regulate themselves almost automatically in accordance with this principle. But to the thinking person, induction and deduction go hand in hand. The nature of justice, *e.g.*, is progressively established by induction but in the meantime it is at every stage a serviceable tool in deduction.

Rational *vs*. reasoned ideas. — We understand now why the terms " thinking " and " reasoning " have come to be used so broadly and loosely with some justice. It is due to the recognition of fragments of the blends of reasoning with other mental processes and of the automatized processes which lead to rational action, whether conscious, subconscious, or crystallized in purely neural dispositions. Our greatest confusion is cleared up when we recognize the difference between rational and reasoned actions or ideas. The vast mass of human and animal behavior is rational, we might say reasonable, but only a very small part of it is reasoned. In the latter sense animals do not reason at all and man but very little.

Imageless thought. — In answer to the question, " Can we think without images?" I should say, " No." On the problem of imageless thought, two facts should be noted even though they be mere opinion. First, many of the processes which we call thinking are so nearly automatic that we are scarcely conscious of any image and there is correspondingly little actual thinking. Second,

the image is a fickle thing to observe and there is much quibbling about terminology. If, for example, a man says that he has had a very vivid dream but did not have any mental imagery, he must be using language in some unreasonable way. On the other hand, if he says that he cannot find in his daily life any use of imagery, we may question the accuracy of his observation and bear in mind that the recognition of the image is like many other great discoveries: it follows a certain order of evolution and some persons are slow in recognizing the new phenomenon.

Reasoning as behavior. — The old term "apperception" has given place to the term "meaning," and the concept "meaning" has acquired its chief vitality through the objective psychophysical methods of study of recent years. The meaning of the concept "blizzard," for instance, consists in a re-living of the individual responses and the images aroused, such as coldness, whiteness, crystal, resistance to wind, and so forth. "Blizzard" has meaning to a person just to the extent that the conceptual imagery arouses reactions appropriate to each of the factors involved, both sensory and affective.

Here is where behaviorism has its stronghold in the treatment of the higher mental processes. It recognizes the responses aroused by the conceptual situation. While this point of view unquestionably is correct and capable of extensive use, it is hopelessly inadequate for two reasons: (1) It fails to recognize the real fact of experience; namely, the mental image in its conceptual array; and (2) as a method of description it is so frag-

mentary that, without introspective help, we should be hopelessly ignorant of mental life.

General view of reasoning. — "To understand any concrete bit of reasoning, one must consider four phases or parts of the process: (1) Every act of reasoning is closely related to the felt need or purpose of the individual at the moment. This is purely subjective in its origin and an expression of much in the earlier history of that individual and in his immediately preceding life. It is connected with the desires, and these go back to early training; with life purpose, however originated; and finally with instinct. The purpose cannot, in its turn, be understood apart from the larger whole of the life of the individual, although the momentary purpose is sufficient to enable one to understand the course of reasoning. (2) The outcome of reasoning is dependent very largely upon the tools that present themselves and upon the other external circumstances of the moment, more particularly upon the way the circumstances of the moment are appreciated and interpreted. The interpretation or appreciation of the situation is very closely connected with the purpose. When one is interested in a problem, one sees in it a certain situation. When the purpose changes, the interpretation differs. The purpose, then, is dependent for its accomplishment upon the material setting, but the setting is dependent for its interpretation upon the purpose. (3) When a purpose and situation are given, some solution of the problem usually suggests itself. The solution will depend upon the connections that have been earlier developed. If the solution is in idea alone, the situation will recall old ideas that have been used in more or less similar situations to solve similar problems. If the solution is a movement, the situation will call out accustomed movements that have been learned in other connections and will apply them to the new problem. In either case the

outcome will be controlled in some degree by the purpose that is dominant. (4) Finally, each solution must be tested. The test will be the actual success of the movement if the solution is an act; it will be the belief, disbelief, or doubt of the suggested solution if the answer is in idea alone." (Pillsbury)

Facts implied. — We have so far regarded the status of reasoning in its formal aspects of thought. Psychologically, we have traced the final analysis to the behavior of images and their neural counterparts in association. We must, therefore, accept the sequel and regard thought as intimately interwoven with all the complex mental processes; as potential action, as the content of feelings, as capable of abbreviation and fragmentation *ad infinitum*, as having a rigid neural basis, as evidenced in organic reactions, and as having an all-pervading counterpart in the subconscious.

CHAPTER XXI

EMOTION

Up to the present stage we have dealt primarily with the cognitive or knowing processes, such as sensation, perception, images, association, and elaboration, and their neural counterparts. But in all of these processes we have observed and spoken freely of the presence of two other aspects; namely, feeling and action. To use the traditional terminology, there can be no knowing without some feeling and action; there can be no feeling without knowing and action; and there can be no conscious action without some element of knowing and feeling. In all mental life the psychophysical organism as a whole is directly or indirectly involved.

It has been said that all action is fundamentally either pushing or pulling — pushing representing all the forms of defense, avoidance, riddance, and escape; pulling representing all the forms of attraction, approach, embrace, and holding. Corresponding to this bipartite division of action we have found two aspects of feeling; *i.e.*, agreeableness and disagreeableness; one corresponding to the movements of attraction, the other to the movements of defense. This feeling has been described as a *leaning* of the psychophysic organism, either in an attitude of attraction or an attitude of repulsion.

This twofold conception of response and leaning of the organism is of fundamental biological significance

because it helps us to explain emotional life in terms of component elemental factors, and therefore aids in the interpretation of human nature as composed of an almost infinite variety of natural reactions, for or against objects, situations, ideas, and other stimuli in behavior.

The term affection may be used to designate the most elementary form of agreeableness or disagreeableness as associating with cognition and action. It is often spoken of as affective tone. When the affective process becomes an object of consciousness, as when we say "I like this" or "I dislike this," it is usually called a feeling; when it is very strong so that it breaks out into marked forms of expression, it is usually spoken of as an emotion; when it is of a contemplative nature we call it sentiment; when it becomes habitual we call it a mood, and when it is uncontrollable we call it a passion. The whole "leaning" aspect of mental life is properly designated as affective life or the affective processes; but the term feeling is still in good usage as a general term.

In the present chapter we shall review some of the fundamental aspects of emotion, discussing in turn the qualities of feeling, the function or the rôle of the central and the peripheral nervous system, the endocrine glands, the autonomic nervous system, and the nature of expression in emotion.

The Qualities of Feeling

The two affective qualities. — As we have assumed throughout, there are two kinds of affective qualities: the agreeable and the disagreeable; the pleasant and the

unpleasant; those that represent the attitude of attraction and approach, and those that represent the attitude of repulsion or escape; and there are only two.[1] You may well exclaim, "Is the quality of agreeableness the same in the taste of ice cream, the contemplation of the starry heavens, or the joy of victory?" Yes. "Is the quality of disagreeableness of the taste of quinine, the fear in a storm at sea, or the agony of defeat, the same?" Yes. The differences within each of these two series lie not in the difference in affective quality proper, but in (1) the knowing factors, (2) the action factors, (3) the intensity and duration of the feeling quality, (4) the stability or oscillation of affective tone, and (5) the infinite modes of combination of factors within each of these variables. For affection, feeling, or emotion, as such, has no content. They always represent an attitude of the organism in knowing and acting.

Ice cream, the starry heavens, and victory are radically different as things known and radically different in the action involved. They also differ in complexity. The one thing which is common to them all (if agreeable) is that they appear in an attitude of attraction. The awareness of this leaning in attitude is the affective tone of consciousness. The application of this principle of interpretation to the disagreeable is analogous.

The stream of mental processes always flows in one direction — from impression into action. In this flow it surges from side to side between the agreeable and the disagreeable. Thus we may regard all mental processes

[1] Many authors differ from this position. Wundt, *e.g.*, appeals to experimental evidence for six; to our two, he adds strain and relaxation, excitation and quiescence.

as being actually or potentially in the threefold aspect of knowing, action, and feeling.

If we may indulge in an artificial way of representation, we may show the relative prominence of each of the three aspects or ingredients in a given mental pro-

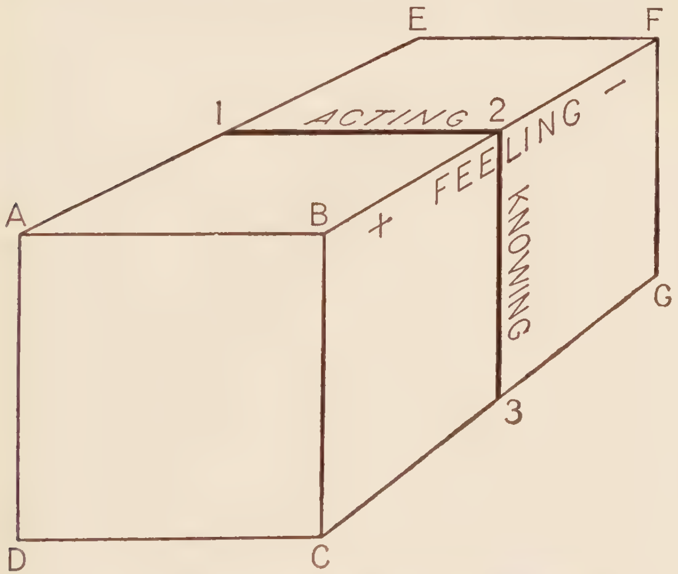


FIG. 21.—Relation of feeling tone to knowing and acting. + agreeable; – disagreeable

cess at a particular moment in a geometrical scheme in which we use the quantitative method to illustrate qualitative relations. In Fig. 21, any ratio of knowing to acting may be designated by a point in the plane 1, 2, 3, or any other plane parallel to it. If the two aspects are equally prominent, this may be represented by a dot at the center of the plane. Any other ratio may

be designated in the same manner, indicating the relative prominence of knowing and action in relation to each other. We assume that all mental processes may be represented in this plane in so far as these two aspects are concerned. Now, if we represent affection or feeling in relief from this plane, — the agreeable (+) toward the plane *ABCD* and the disagreeable (−) toward the plane *EFG*, in proportion to the intensity of feeling, — then any proportion of a knowing-feeling-acting blend may be represented by a single point within this three-dimensional figure. For example, action 20 per cent to knowledge 80 per cent, agreeable to the extent of 50 per cent on an arbitrary scale, would be indicated by a point halfway out toward us, from the middle plane, 80 per cent of the distance from the left-hand side, and 20 per cent of the distance from the bottom.

We are here applying to the analysis of feeling the same principles which we applied to the analysis of perception; as in taste, smell, or pressure, where we found it possible to account for countless variations of perception through these senses in terms of a small number of qualities. It takes our conception of feeling away from the vague and uncoördinated and gives us a definite mode of organizing observed facts in theory and experiment.

This figure is intended to visualize five ideas, for which we contend and which are matters of current controversy: (1) the twofold quality of feeling; (2) the actual or potential threefold aspect of all mental processes; (3) that feeling is not a content in itself, but is always an aspect of the knowing-action process;

(4) that feeling is not elemental; and (5) that affective qualities probably oscillate rather than mix.

These affirmations take sides on historical bones of contention. At the present stage of scientific knowledge on the subject, they are presented tentatively, mainly as a starting-point for thought and discussions. Present space does not permit us to enter upon the controversy involved in these theses but a word of explanation of each may be in place.

The pleasure-pain theory. — The twofold conception of affective quality, as presented in the pleasure-pain theory, has a long and interesting history. Those who are familiar with this history will find that the present theory is perhaps free from the principal objections which were justly hurled against that theory in the past. The sponsors for the old pleasure-pain theory were aiming in the right direction, but they did not have the advantage of the penetrating insight gained through experimental analysis in the laboratory, particularly the objective methods in behaviorism. Nothing has given better support to our theory than the ultra-modern attempt to construct a psychology in terms of stimulus and response.

The twofold division is based on the fact that biologically all stimuli may be divided into two classes: beneficent and noxious. The former effect responses of attraction, approach, encompassment, and support; the latter, responses of repulsion, escape, shedding, suppression, fight or flight. But the aggressive and the defensive movements may be actual or imaged movements. Both occur also for the centrally aroused processes of

memory, imagination, and thought, just as for sensory impressions.

The threefold aspect. — Much misunderstanding has come from the tendency to regard feeling as a mental process in itself. There can be no feeling except a feeling about something, real or imagined, in response to something. Fear is always about something to be feared; laughter about something laughable. The object of the emotion is always present in emotion as the thing known, and, hence, cognitive. There can be no emotion without response. There is action in the coolest knowing process; and, to the extent that the situation is emotional, the knowing runs into overt action. Add to this the fact that all knowing-action results in awareness of attitude for or against the object, situation, or idea — in agreeableness or disagreeableness — and you will find in every complex mental process the threefold aspect of knowing, acting, and feeling. The content is represented in the knowing aspect, the action in the response and the resulting attitude toward the content, and the feeling in our awareness of attitude.

Elemental. — It has often been held that affection is an elemental experience for emotion, as sensation is elemental for cognition. The issue is not easily settled; but, if it is true that there is always a cognitive element present in all affective states, then the affective quality is not a new kind of experience but merely the tone of something, however diffuse and indifferent the cognitive aspect may be.

Fluctuation *vs.* mixture. — Do the agreeable and disagreeable mix in complex feeling and emotion, or is

there an oscillation from one affective tone to the other? While the question cannot be answered positively, evidence from the physiological point of view would tend to favor the fluctuation theory.[1] Our experimental knowledge of the nature of perception favors this view. For example, in the illusion of reversible perspective the physiological conditions for change may and do take place several times a second and conflict, but there is a lag in recognition so that the shift seldom takes place faster than once in four or five seconds. The affective tone is determined by the beneficent or noxious character of the object as recognized in the perception or image, which may flit through the focus of consciousness "as fast as thought"; but, on account of the lag of recognition, the affective tone changes very much more slowly than the shift in imagery.

Rôle of the Central Nervous System, the Sense Organs, and the Muscles

In all our normal life, all the senses are continuously in play; the associative processes are in constant activity, and all the muscles are continuously in more or less tense tonus or action. The psychophysical organism is therefore continuously registering masses of

[1] Speaking of reflexes, Sherrington says, "It would seem a general rule that reflexes arising in species of receptors which considered as sense-organs provoke strongly affective sensation, *caeteris paribus*, prevail over reflexes of other species when in competition with them for the use of the 'final common path.' . . . Unlike reflexes have successive but not simultaneous use of the common path. Expressed teleologically, the common path, although economically subservient for many and various purposes, is adapted to serve but one purpose at a time. Hence it is a coördinating mechanism and prevents confusion by restricting the use of the organ, its minister, to but one action at a time. . . . The resultant singleness of action from moment to moment is a keystone in the construction of the individual whose unity it is the specific office of the nervous system to perfect."

impressions from the environment without and the organism within, the web of associative life is continuously reeling off its complex pattern, and the physical organism as a whole is constantly in a process of changing movements and tensions. Only an infinitesimally small number of these processes become focal in consciousness; the vast mass blend or fuse into a sort of ensemble impression which constitutes in large part the content of feeling.

EXERCISE. — *Imagine yourself stepping out from the flowers and shrubs in your front yard on a beautiful spring morning and shaking hands with a passing friend as you say, "Good morning." Write a compact 100 word statement of what would be likely to take place in you during fifteen seconds of this act of greeting in accordance with the paragraph you have just read. Do this before reading further!*

Even if we assume that you were dominantly in an attitude of agreeableness and that we regard only the pleasurable aspect, the situation was still one of enormous complexity and richness. During these few seconds every sense organ in your organism was in play; your past, present, and future appeared in flashes of association; and every muscle was in tension or action. Your eyes not only saw your friend in general, but a number of features in particular and noted the expression of his countenance; and the whole environment within the visual field played upon the eyes in light and color giving information not only about objects around, but a general consciousness of beauty of nature, a sense of orientation, and a feeling of comfort from the light, verdure, and chromatic display in the surroundings. There was the sound of your friend, the twittering of birds, the whiz

of an automobile, the subdued conversation of pedestrians in the distance. The perfume of the dew-laden shrubs, flowers, grass, and soil came heavily with every whiff of air. Perhaps the taste of the breakfast coffee with cream and sugar still lingered in the mouth. The sensations of position, movement, activity of internal organs, and balancing rushed in through hundreds and hundreds of sources. Particularly conspicuous were the sensations of speech movements and handshaking. The touch on the soles of the feet, contact with clothing, and the whisk of the wind reported profuse impressions. The comfortable temperature, different from the surrounding air, on the face, under the clothes, and in the mouth and nostrils, furnished an important basis for feelings of comfort. Even various pains, such as smarting from the wind or adjustment to the light, might have added to the pleasurable impressions. With these sensory impressions came a flood of images or impressions more or less remotely associated with them; images of actual or imagined situations concerned with each of the present situations. All these impressions from without and within tended to run into action either of specific muscle fibers or organs, or in more or less grouped or massed muscular tensions.

This attempt to enumerate the impressions and actions of the moment strikes you as very incomplete. The situation was vastly richer and more complex than that conveyed by your description. Still, probably during these few seconds only a few things were adequately focal in your consciousness, such as the recognition of the friend, some particular features of his dress or

action, movements and sounds of the greeting, the presence of a tree or shrub. All the rest of the countless masses of other factors remained in the more or less remote background of consciousness. But in so far as these mass impressions were indications of a favorable situation for the organism, they resulted in a feeling of well-being and comfort, which, although not necessarily an object of consciousness in itself, manifested itself in your attitude and general expression as in smile, affability, and general expression of well-being.

Such a play upon our sensorium and such massive, undifferentiated reactions are typical of our waking life — and, in large part, of sleep. It would be utterly impossible for us to have clear consciousness of each of these processes individually. The more or less inceptive actions of muscles coöperate or counteract in all degrees of complexity with the result that the total effect of the thousands of muscular adjustments may in a moment result in a state of feeling of safety, comfort, well-being, and good will. Here, then, is one aspect of the background of affective life. A similar picture may be drawn from the point of view of the disagreeable and defensive aspect. For all this the cerebro-spinal nervous system furnishes an adequate basis. *Affective tone, feeling, and emotion are due in large part to undifferentiated mass impressions for which we find an adequate basis in the mass reactions of the cerebro-spinal nervous system.*

The Ductless Glands

There are glands in human and animal bodies known as ductless because they discharge directly into the

blood. They are often spoken of as glands of internal secretion, or endocrine glands. The essential elements in the secretion or incretion which they throw into the blood are known as hormones, meaning to set in motion. In a most general way, their function seems to be to act as control organs for all other organs that carry on vital processes in the body. They either accelerate or retard vital activity and therefore serve the purpose of speeding up or retarding vital processes. Among these are the thyroid, the parathyroid, the adrenal glands, the pituitary body, the gonads, the thymus, the pineal gland, and the pancreas.

The ductless glands are either organically a part of, or genetically related to, the most primitive form of nervous system, the autonomic system; and they act chiefly through the involuntary or smooth muscles as distinguished from the striped or skeletal muscles which are actuated by the central nervous system. They are highly organized into one interlocking system which serves the purpose of control in the way of power to speed up, slow down, or hold the life functions in normal equilibrium. Most of them are small; some of them have been unknown until recently. Others, such as the pineal gland and pituitary body, have been regarded as rudiments which have no present function, but are now proved to have such vital function that injury to one of them may mean immediate death. Experiment has shown that each of these glands is essential to the maintenance of life and the control of equilibrium of body and mind. They therefore play a very important part as a groundwork of affection, feeling, and emotion.

Glandular treatment in cretinism. — Since Barnum introduced the Tom Thumb family, circuses have found a profitable attraction in the exhibition of midgets. These midgets are often the result of a disease called cretinism which is rather rare in this country. In a certain valley in Switzerland, a large part of the population is suffering from this disease. The mark of cretinism is essentially a stunted growth. A child, apparently normal, may stop growing in nearly every part of the body and mind at an early age, so that by the time he is of age, he may be less than two feet tall and so stunted in mind and body as to be regarded as more or less of a helpless idiot, — crimped, uncouth, and apparently hopeless.

Until thirty years ago this disease was regarded as incurable, but now comes the wonder of modern science. If begun early enough under favorable circumstances, the daily feeding of a little pellet of extract from the thyroid gland of a sheep starts and sustains the growth of mind and body so that the individual may rise to full stature, develop full mentality, and be capable of approximately normal education. The cause of this disease lies in the inadequacy of the little gland in the neck known as the thyroid gland. The cure and the maintenance of normal growth to adult life consists of supplying to the system, through feeding, that chemical ingredient which normally should have been furnished by this gland.

A cretin, or one suffering from related diseases, may, under this treatment, make the growth of fifteen years in half that period and may pass in society as indistinguishable from a normal individual, may work and

play, enter into society and business, marry, and be happy. But the supply of this thyroid extract throughout life is as necessary as the supply of nourishment; for the lack of it will immediately result in deterioration of body and mind.

The discovery of this function of the thyroid and of glands closely associated with it has greatly modified our interpretation of the bodily mechanisms which control the growth and development of the brain, and furnish the explanation of the energizing, differentiation, and control of the nervous system in normal activity and, therefore, of the mind. We must for this reason gain a working conception of such glands for an understanding of the functions of the organ of the mind.

The thyroid gland. — The thyroid gland consists of two masses of cells above the windpipe, close to the larynx. In childhood they may often be noticed because they swell; the disease called goiter consists of a pathological swelling of the thyroids. The secretion from these glands is known as thyroxin in which the principal ingredient is iodine. This secretion seems in a marvelous way to control the speed of living. It has been maintained on the basis of experiment that the more of this secretion one has, the faster one lives; the less one has, the more slowly one lives. When thyroxin is discharged into the blood, more oxygen and food material are burned up; more energy is liberated; metabolism takes place faster; the individual thinks, feels, and acts more quickly. Thus it has been compared to the accelerator, the primer, and the carburetor which determine the efficiency of the gas engine, for it not only

facilitates the using up of energy, but also frees energy for the more rapid supply of the energies dissipated. It not only controls the speed of the expenditure of energy, but also accelerates the speed of the production of such energy; it supplies the mechanism not only for the quantity of output of all energy, but also the apparatus for varying the amount of energy available. It determines in large part the rate at which the tissues of the cell shall burn themselves up.

Feeble-mindedness and retardation. — Thus it comes about that not only the gross development as illustrated in thyroid treatment for cretinism, but a great variety of minor diseases may be caused by disturbance in the supply of the thyroid ingredient and may be cured by the proper administration of thyroid extract. We have spoken of cretinism, because that is the most extreme case. But the greatest significance for psychology lies in the fact that the principle here illustrated operates in all degrees from the extreme disease down to the normal; so that in a so-called normal community, we can observe the effects and traits of thyroid deficiency in all degrees of transition, and the control of the countless slight disturbances lies in the means that control the extreme disease. This applies particularly to the large group of so-called feeble-minded in various degrees. Up to the present time we have been taught that feeble-mindedness is incurable. It has certainly proved resistant to educational treatment. But if cretinism, one of the most extreme forms of feeble-mindedness, can be remedied in some cases, may not the situation be very much more hopeful for those who are feeble-minded

or retarded in a lesser degree? It may be that many of the cases of retardation in our schools are due to diseases of this gland and are amenable to physical treatment. In many parts of this country, notably in the region of the Great Lakes, we are now feeding iodine to school children to avoid goiter troubles. In short, it now seems probable that many of the diseases of arrested development, degeneracy, and aberration have their chief manifestation in mental disturbances or defects; and these disturbances can be remedied in many cases by the stimulation of the proper organ of internal secretion, or the checking of it, as the case may be.

From the point of view of development, we find that thyroid as an energizer is responsible for many peculiarities and abnormalities of growth. It is well known that different parts of our body develop most rapidly at different periods according as the supply of the thyroid secretion is excessive or lacking at that particular period. A given organ may develop abnormally large or small dimensions.

To add to the weirdness of this situation, we may say that the essential ingredient in the thyroid secretion can now be produced in the chemical laboratory, and it has been demonstrated that this artificial product will have the same effects as the actual secretion of the gland in its normal function or the administration of the gland product secured from living tissue. Experiment has also shown that we may facilitate the secretion from this gland by a gentle stroking on the surface of the neck. Where there is thyroid heredity, the feeding of thyroid to the pregnant mother has the same

effect as the feeding of thyroid to the growing child. This is true of both human beings and animals.

Hyperthyroidism. — It is evident that both by excessive production of this secretion from the gland itself under abnormal conditions and by excessive feeding of thyroid extract, great dangers to life are incurred. The condition of excess of supply of this secretion is known as hyperthyroidism. Such condition is, in turn, often brought about by great sorrow, great joy, and great excitement. Thus it has been shown that one of the calamities of the Great War in large bodies of the population was this production of hyperthyroidism which in turn resulted in the excessive discharge of energy, and neurotic, high-strung, unstable, nervous conditions of individuals.

The adrenal glands. — These ductless glands have been called the glands of combat, emergency energy, and preparedness. They lie on the surface of the kidneys and throw a substance called adrenalin into the blood. Excitement, especially fear and rage, will bring about the discharge of adrenalin and this stimulates the nervous system. This adrenalin may be extracted from one animal and injected into the blood of another animal under observation. And even more striking is the fact that the adrenalin can be prepared artificially in the chemical laboratory and, when injected into the circulation of the blood, it produces the same effects as the discharge from the gland of the animal itself or the extract from another animal. It has also been shown that in strong emotion, such as fear, the emotion itself produces an increase of natural adrenalin in the blood. The more combative and pugnacious and excited the animal

is, the more adrenalin it has. The significant thing here again is not the fact that extreme emotion may be produced in this way, but the fact that this principle operates in all degrees from normal placidity to the most intensive emotional upset.

As a result of adrenalin, the nerve cells become more sensitive, more sugar is poured into the blood from the liver, more red blood corpuscles are thrown into the circulation, the blood is redistributed, being withdrawn from the internal viscera and hurried to the skeletal muscles and the brain, the heart beats more strongly, the eye sees more keenly, the ear hears more distinctly, the breathing is more rapid, the temperature rises, the hair of the head and body become erect, the skin gets moist and greasy, the pupils dilate, the blood vessels are constricted, and the activities of the alimentary canal are inhibited.

"These mechanisms of response are purposive, serving as emergency functions, fitting the individual for struggle. Sudden liberation of sugar, the best source of muscular energy, is like filling up the furnace to gain increased heat in the boiler. Contraction of the blood vessels is favorable to muscular action. Increased coagulation of the blood is favorable to healing of a wound." (Cannon)

"A picture of its activity in the evolutionary scheme of struggle and survival is something like the following: meeting an enemy, the animal is put in danger. It must fight or flee for its life. In either case, certain conditions must be fulfilled if the body of the animal endangered is to be saved. To prevent injury to itself and to do as much injury as possible to the foe — that becomes its immediate urge and necessity. Of the two

animals, if in one the heart should begin to beat more strongly, the blood pressure to rise, the blood to flow more rapidly through the attacking instruments, the muscles, the teeth and the claws, the brain and the eyes, while the other animal experienced none of these, the former would be the victor in the fight or flight. Adrenalin may be looked upon as the invention for the mobilization at a moment's notice, or as we say, after generations of use, by instinct, of all these visceral and blood advantages for combat or flight." (Berman)

The mechanism of fear. — " We may therefore visualize a mechanism of fear. An instant excess of adrenalin occurs in the blood of, say, a cat when it is alarmed by the sight of a dog. In that cat, at the image of its hereditary enemy, certain brain cells discharge. A nerve tract, in use as the line for that particular message in a hundred thousand generations of cats, whirrs its yell, to the medulla of the adrenal gland. Through the tiny, solitary veins of the glands, an infinitesimal quantity of the reserve adrenalin responds. And with what effect! The blood, that primary medium of life, the precious fluid that is everything, must all, or nearly all, be sent to the firing line, the battle trenches, the brain and muscles, now or never. So the blood is drafted from the nonessential industries — from the skin where it serves normally to regulate the heat of the body — from the digestive organs, the stomach and intestine, which must forsooth stop now, since if the organism will die, their last effort of digestion has been done — from the liver and spleen, great chemical factories in normal times, but now of no moment. Besides, should they be wounded, it is better they should be bloodless, and so run the least chance of bleeding to death, or getting infected, for the more tissue there is around, the greater the danger of infection. So, like the skin, the liver which usually holds in its great lakes and vessels about a quarter of all the blood in the body, is almost drained and blanched.

At the same time, its great storehouses of sugar open their sluices and pour into the blood, increasing its sugar content by about a third because the combustion of sugar is the easiest way of getting energy free in the cells, sugar being the most quickly burned up of all the foods, and so the great food of the muscles and the heart. The poisons of fatigue, acid products of the contraction of muscles, are antagonized and neutralized by substances formed in the course of the oxidation of the sugar. Adrenalin, too, is directly a fatigue antagonist. It causes the blood to clot faster than under ordinary circumstances. It erects the hair of the animal, and dilates the pupils of the eyes. There is an increase of the apparent size, all of which are to intimidate the enemy, like an Indian's painting of his face blue and green. It also — but what else does it not do?" (Berman)

Adrenal insufficiency. — Shock, collapse, heart-failure, and sudden death have sometimes been attributed to adrenal insufficiency. One of the effects of the disease of the adrenal glands is the feeling of muscular inefficiency, and many forms of nervous disorders may be due to inadequate stimulation from the adrenal glands.

Other ductless glands. — Having set forth the function of the thyroids and the adrenals as examples of endocrine activity, we may merely mention other glands of which less is known. The *pituitary body* is a small, soft organ at the base of the brain. Until recently it has been regarded as vestigial; but we now know that it controls the tonus of the involuntary muscle fibers and blood vessels. The removal of this gland means death in two or three days. The *pineal* gland, another small, single body lying in the median plane at the base of the brain, it is now believed, controls in a vital way the brain

and sex development and has therefore been called the gland of adolescence and puberty. It was this gland that Descartes thought might be the "seat of the soul." Genetically it is the rudiment of a primitive eye. The *gonads* are minute glands located on the sex organs. They seem to control in some mysterious way the development and function of sex in early life, and also secondary sex characters. The *thymus*, a small gland on the windpipe, has a function similar to that of the gonads and has been called the gland of childhood because it influences the early development of the child physically and mentally. The *parathyroids* lie embodied with the thyroids. As the thyroid controls the iodine balance in the body, so the parathyroids seem to control the lime supply in metabolism. The ductless part of the *pancreas* controls the sugar release in metabolism.

"Thus, the growth of the brain is presided over by the adrenal cortex, the thyroid, the thymus, and the pituitary. They determine the size of the brain, the number of its cells, the complexity of its convolutions and the speed of its chemistry, which means the speed of thought and memory and imagination. As its directorate, therefore, they may be entitled. The disturbance of one of them means the disturbance of all of them, and a consequent deleterious effect upon the brain. Now take the burning up of sugar in the organism, the great material source of energy, which is controlled by the pancreas, the adrenals and the liver, the thyroid and the pituitary. Together they form the directorate of sugar metabolism. But, as is evident from a glance at the membership of the growth directorate, and comparing it with the directorate of sugar metabolism, there are some members who are present on both boards. An infection, an illness,

an ailment, an exaltation or intoxication of such members will produce reverberations in both directorates. A disturbance of sugar metabolism might then cause a disturbance of growth. The advantages and disadvantages are before us of having, in the glands of internal secretion, an interlocking directorate, rulers over all the varied and manifold activities of the organism." (Berman)

It is the central nervous system which is active, in so far as we have conscious emotion; but it is these glands of internal secretion that have the power to open the emergency valves, start the engine, supply emergency fuel, and set the whole organism into emergency response.

The endocrine phenomena present a new field for investigation. Relatively little is known on the basis of experiment. The wildest enterprises of drug manufacturers, unscrupulous and ignorant practitioners, and the scramble of deluded patients can now be observed. Yet there are certain fundamental facts which are firmly established and have a very far-reaching significance in animal biology, medicine, psychology, and education.

We have now to recognize the effect on emotions not only of the endocrines, but also of germs. Various germs in the system operate to facilitate or inhibit the normal processes of each and every organic action. Thus mental life is at the mercy of germs not only of infectious diseases which may result even in unconsciousness, but in a more significant way in the fact that the body is a carrier of a vast variety of germs of more or less insidious, toxic capacity which tend either to facilitate or

check the life processes of which the brain activity and therefore mental activity is one.

The autonomic system. — We have two nervous systems — the cerebro-spinal system and the autonomic system; the latter, so called because it acts automatically, is sometimes called the sympathetic system. It is composed of a network of nervous tissue with clusters distributed over the viscera as partly shown in the Appendix, Fig. 42. As the central nervous system controls the striped or skeletal muscles, so this system controls the smooth or involuntary muscles and glands, particularly the endocrine system of which it is an integral part. As we have seen in the above examples of the function of these glands, this system exercises a profound influence upon the central nervous system, particularly in those situations which result most characteristically in affective tone, feeling, and emotion.

Bodily Expression in Emotion

That the rich and complicated activity which takes place in emotion is the result of inherited associations in the form of instinctive reactions was well stated on the basis of direct observation by Darwin when he said:

"Men, during numberless generations, have endeavored to escape from their enemies or danger by headlong flight, or by violently struggling with them; and such great exertions will have caused the heart to beat rapidly, the breathing to be hurried, the chest to heave, and the nostrils to be dilated. As these exertions often have to be prolonged to the last extremity, the final result will have been utter prostration, pallor, perspiration, trembling of all the muscles, or their complete relaxation. And now, whenever the emotion of fear is strongly felt,

though it may not lead to any exertion, the same results tend to reappear, through the force of inheritance and association."

On the basis of recent laboratory experiments in the physiology of emotions, Crile now reaffirms this principle with illuminating evidences, showing that emotion is the result of inhibited instinctive action.

"When our progenitors came in contact with any exciting element in their environment, action ensued then and there. There was much action — little restraint or emotion. Civilized man is really in auto-captivity. He is subjected to innumerable stimulations, but custom and convention frequently prevent physical action. When these stimulations are sufficiently strong but no action ensues, the reaction constitutes an emotion. A phylogenetic fight is anger; a phylogenetic flight is fear; a phylogenetic copulation is sexual love; and so one finds in this conception an underlying principle which may be the key to an understanding of the emotions and of certain diseases. . . . So strong is the influence of phylogenetic experience that though an enemy to-day may not be met by actual physical attack, yet the decks are cleared for action, as it were, and the weapons made ready, the body as a result being shaken and exhausted. The type of emotion is plainly declared by the activation of the muscles which would be used if appropriate physical action were consummated. In anger the teeth are set, the fists are clenched, the posture is rigid; in fear the muscles collapse, the joints tremble, and the running mechanism is activated for flight. . . . The emotions, then, are the preparations for phylogenetic activities. If the activities are consummated, the fuel (glycogen) and the activating secretions from the thyroid, the adrenals, and the hypophysis are consumed. In the activation without action,

these products must be eliminated as waste products, and so a heavy strain is put upon the organs of elimination. It is obvious that the body under emotion might be clarified by active muscular exercise, but the subject of the emotions is so strongly integrated thereby that it is difficult for him to engage in diverting, clarifying exertion. The person in anger does not want to be saved from the ill effects of his own emotion; he wants only to fight; the person in fear wants only to escape; the person under sexual excitement wants only possession."

The results of experiments bearing on this issue are best summarized by Crile as follows:

"Laboratory experiments show that in an animal driven strongly by emotion the following changes may be seen: (1) a mobilization of the energy-giving compound in the brain-cells, evidenced by a primary increase of the Nissl substance and a later disappearance of this substance and the deterioration of the cells (Figs. 5 and 13); (2) increased output of adrenalin, of thyroid secretion, of glycogen, and an increase of the power of oxidation in the muscles; (3) accelerated circulation and respiration with increased body temperature; (4) altered metabolism. All these are adaptations to increase the motor efficiency of the mechanism. In addition, we find an inhibition of the functions of every organ and tissue that consumes energy, but does not contribute directly to motor efficiency. The mouth becomes dry; the gastric and pancreatic secretions are lessened or are completely inhibited; peristaltic action stops. The obvious purpose of all these activations and inhibitions is to mass every atom of energy upon the muscles that are conducting the defense or attack."

A theory of emotion in terms of facts like the above is admirably summarized by Lloyd Morgan:

"I may be allowed here to recapitulate my own view

of the matter. When a specific situation affords an appropriate constellation of stimuli, there issue reflexly from the subcortical centers two sets of efferent impulses, (1) those which evoke a specific mode of instinctive behavior, including those motor responses which constitute much of the so-called emotional expression; (2) those which evoke visceral disturbance — changes of heart-beat, and of the respiratory rhythm, modifications of the digestive and glandular functions, alterations in the peripheral vascular flow, a diffused influence on the general coenæsthesis and so forth. From all this complex of bodily changes, afferent impulses come into the central nervous system, and when they reach the cortex, qualify the experience of the presented situation and thus complete the instinctive experience with its accompanying emotional tone." (Morgan)

"The close relation between emotion and muscular action has long been recognized. Emotion 'moves' us, — hence the word itself. If developed in intensity, it impels toward vigorous movement. Every vigorous movement of the body . . . involves also the less noticeable coöperation of the viscera, especially of the circulatory and respiratory. The extra demand made upon the muscles that move the frame involves a heightened action of the nutrient organs which supply to the muscles the material for their energy. The researches here reported have revealed a number of unsuspected ways in which muscular action is made more efficient because of emotional disturbances of the viscera. Every one of the visceral changes that have been noted — the cessation of processes in the alimentary canal (thus freeing the energy supply for other parts); the shifting of blood from the abdominal organs, whose activities are deferable, to the organs immediately essential to muscular exertion (the lungs, the heart, the central nervous system); the increased vigor of contraction of the heart; the quick abolition of the effects of muscular

fatigue; the mobilizing of energy-giving sugar in the circulation — every one of these visceral changes is directly *serviceable in making the organism more effective in the violent display of energy which fear or rage or pain may involve.*" (Cannon)

These quotations set forth admirably the ascertained facts from the points of view of the experimental study of expression in emotion. The essential features are these: (1) Emotion is a crisis arising as a result of instinctive responses which do not have any adequate outlet; (2) these responses, in addition to the conscious voluntary or habitual reactions, are (*a*) the instinctive responses through the skeletal muscles under control of the central nervous system, which have been mobilized in the life of species (phylogenetic) in the form of reflexes representing purposive responses that have survived because useful and much used in the race, and (*b*) the organic reactions, which ordinarily take place through the autonomic system to fit the organism for emergency action; (3) consciousness of these responses or their results and the general intensifying of the consciousness of the result of the organic reactions enter into the awareness of the situation, which is emotion.

The James-Lange theory. — For the last forty years discussion of emotion has centered around the theory proposed more or less independently and simultaneously by James and Lange. James' statement of the theory is as follows:

"My theory is that *the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur* IS *the emotion.* Common sense says, we lose our fortune, are sorry and weep; we meet a bear, are frightened and run; we are insulted

by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is incorrect, that the one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble, because we are sorry, angry, or fearful, as the case may be."

Was James right? His general principle has not been disproved, but it has been found to be fragmentary and needs to be amplified. To restate our own view in this matter, let us go back to our conception of *meaning* in perception. This is couched partly in terms of images of associated objects and images of responses to them, and partly in terms of sensation of actual or inceptive movements, both of which are set in masses of reflexes. The former may be fairly adequate without the latter. Perception differs from emotion mainly in degree of feeling. The affective aspect is present in perception as certainly as in emotion. As the affective aspect increases in intensity the meaning aspect, in purely cognitive terms, is correspondingly enriched. The perception of a thorn on the stem of a rose is quite cool in comparison with the perception of a rattlesnake. Both present danger of a sting, but in the latter the awareness of conditions, the assumption of meaning, and the anticipation of dangers, is vastly richer than in the former. The clear images of leap, sting, results of poisoning, and possible modes of escape are conspicuously strong in the latter. These are set in much more massive non-focal flux of images, which blend into and form a set-

ting for the affective tone; and all of this may take place without the injection of the sensory report from the response. There is then a gradual transition from the purest non-affective perception to the most intense emotion. Ordinarily the sensory report from the reaction and the acceleration or inhibition of the neural processes through the autonomic system takes the form of a diffuse awareness of the attitude of the organism and this constitutes a dominant aspect of the emotion as a whole. It was this that James stressed; but, as has been shown, this is only a part of the experience of emotion.

The Classification of Feelings

It is possible to classify any group of phenomena in as many ways as we have purposes to serve. Thus, we may classify the population of a city on the basis of sex, color, occupation, club or church membership, financial rating, time of residence, location of residence, etc.; and each classification, though entirely different from every other, may be perfectly correct. In the same manner, we may construct and recognize for various purposes a great variety of classifications of the feelings and emotions.

The bipartite classification, into the agreeable and the disagreeable, which runs through the foregoing treatment in this chapter, is fundamental; but for many purposes it does not give sufficient detail. Another fundamental type of classification is the genetic, in which we construct a sort of family tree indicating the origin and progressive differentiation of feelings and emotions in the process of evolution, thus indicating their history and relationship. Undoubtedly the most satisfactory

general classification of emotions should be analogous to our biological classification of plants or animals in which we make a progressive series of differentiations, starting with the group as a whole and ending with fine ramifications which identify the individual. Mercier devoted a large volume, *The Nervous System and the Mind*, published in 1888, to the development of such a classification. This volume has not attracted the attention that it deserves, partly because it is written in an extremely technical and obscure style. I have simplified his terminology and have reduced his elaborate treatment to an outline representing a classification of feelings and emotions. In condensing from the original, many distinctions and qualifications are lost and a few are omitted on the ground that they are manifestly incorrect. The sample of this classification is submitted not as an approved or adequate grouping of feelings, but primarily as a suggestion indicating the probable trend of future organization within this field, and as a very excellent basis for exercises in the critical discussion of classification.

His first large division in this classification is made on the basis of *purpose served*, in which he recognizes three large groups: (I) the conservation of the organism, (II) the conservation of the species, and (III) the conservation of the social group. I present here only Group I of this classification, partly because that is adequate to illustrate this principle of classification, and partly because groups II and III are not regarded as satisfactory. The following classification deals, therefore, only with those feelings and emotions which serve the purpose of conserving the organism.

A Biological Classification of Feelings and Emotions

Adapted from Mercier, *The Nervous System and the Mind.*

I. Those which primarily affect the conservation of the organism [1]
- *A*. Initiated by the environment
  - 1. Correspondence direct: The affective tone of the sensations
    - Light, color, tone, taste, smell, pressure, strain, cold, warmth, equilibrium, pain
  - 2. Correspondence indirect: Feelings and emotions proper
    - *a*. Antagonism: Agent known as actively noxious and of
      - 1) Overwhelming power, and
        - *a*) Does not elicit counteraction — *Terror*
        - *b*) Elicits counteraction which
          - Is incipient — *Desperation*
          - Is voluntarily suppressed — *Resignation*
          - Becomes actual and is
            - Successful — *Triumphant Exultation*
            - Unsuccessful — *Despair*
        - *c*) Is not known with certainty — *Hope*
      - 2) Superior power, and
        - *a*) Does not elicit counteraction — *Fear*
        - *b*) Elicits counteraction which
          - Is incipient — *Courage*
          - Is voluntarily suppressed — *Patience*
          - Becomes actual and takes a passive form — *Stubbornness*
          - Is successful — *Triumph*
          - Is unsuccessful — *Defeat*
        - *c*) Is not known with certainty — *Apprehension*
      - 3) Approximately equal power, and
        - *a*) Does not elicit counteraction — *Hate*
        - *b*) Elicits counteraction which
          - Is incipient — *Anger*
          - Is delayed — *Revenge*
          - Is voluntarily suppressed — *Patience*
          - Becomes actual, and takes a passive form — *Sulkiness*

[1] Such terms as environment, organism, and agent are here used to denote either physical or mental facts or both. Thus, the social theory, belief, or superstition of the community is a part of the mental environment and may be regarded as an agent, affecting either the physical or mental organism or both.

Of moderate intensity	*Rage*
Of extreme intensity	*Fury*
Is successful	*Victory*
Is unsuccessful	*Mortification*
c) Is not known with certainty	*Suspicion*
4) Inferior power, and	
a) Does not elicit counteraction	*Annoyance*
b) Elicits counteraction which	
Is incipient	*Vexation*
Is delayed	*Resentment*
Is voluntarily checked	*Meekness*
Becomes actual, and is	
Successful	*Satisfaction of Success*
Unsuccessful	*Mortification*
5) Insignificant power, and	
a) Does not elicit counteraction	*Contempt*
b) Elicits counteraction	*Scorn*
b. Repugnance: Agent known as passively noxious	
1) To the taste, and	
Moderately noxious	*Disgust*
Intensely noxious	*Loathing*
2) In other ways, and	
Not of superior power	*Dislike*
Of superior power	*Abhorrence*
Of overwhelming power	*Horror*
c. Kindly feelings: Agent known as beneficent	
1) Actively, and	
Not of overwhelming power	*Gratitude*
Of overwhelming power	*Reverence*
2) Passively, and	
Not of overwhelming power	*Liking, Affection*
Of overwhelming power	*Devotion*
d. & *e*. Grievous and joyous feelings: An event known as	
1) Noxious, and	
Distant in time	*Anxiety*
Impending	*Dread*
Imminent	*Alarm*
Does not occur	*Relief*
Has happened	*Anguish, Grief, Sorrow, Regret*
2) Beneficent, and	
Impending	*Pleasurable Anticipation*
Imminent	*Eagerness*
Does not occur	*Disappointment*
Has happened	*Joy, Delight, to Gratification*

B. Initiated by the organism
- *a*. The affective phase of conation
- *b*. The feeling of effort
- *c*. The feeling of abstract sense qualities, such as resistance hardness, softness, elasticity
- *d*. Feelings of content and discontent: relation of activity to outlet
  - 1) Activity exceeds outlet
    - In the case of a single activity — *Desire*
    - In the case of many activities — *Ennui*
    - When the disproportion is prolonged — *Discontent*
  - 2) Outlet is proportional to activity
    - Single activity — *Satisfaction*
    - Many activities — *Contentment*
  - 3) Activity has found outlet in excess
    - Single activity — *Satiety*
    - Many activities — *Blaséness*
- *e*. Feeling of freedom and restraint: relation of activity to obstacle
  - Obstacle, as compared with activity — *Freedom*
    - Insignificant
    - Overwhelming — *Restraint*
    - Equal — *Determination*
- *f*. Feeling of power: relation of exertion to effect
  - Exertion as compared with effect
    - Insignificant — *Power*
    - Slight — *Ease*
    - Considerable — *Difficulty*
    - Overwhelming — *Impotence*
- *g*. Feelings corresponding to the ratio of success to failure
  - 1) Success predominating
    - In important matters — *Self-reliance*
    - In small matters — *Complacency*
  - 2) Failure predominating
    - Decidedly — *Depression*
    - Greatly — *Despondency*

Taking the first of these, we divide them into *A* and *B*, according as they are initiated by the environment or by the organism. Group *A* we divide into 1 and 2, according as the correspondence to the environment is direct or indirect. Group 1 embraces what we may call the affective tone in perception. Group 2 may be

divided on the basis of the character of the agent, according as the agent is (*a*) actively noxious, (*b*) passively noxious, (*c*) beneficent, or (*d*) and (*e*) mixed. The first of these may be again subdivided on the basis of the power of the noxious agent, according as it is recognized as overwhelming, superior, equal, inferior, or insignificant. The first of that subdivision may be divided according as the noxious agent elicits or does not elicit counteraction, or is not known with certainty. Where the agent elicits counteraction, it may be incipient, voluntarily expressed, or actual. If actual, it may be successful or unsuccessful.

Let us illustrate further the significance of this sort of a classification by showing how it enables us to define a feeling with precision. Following this outline, we get this definition of the feeling of *terror:*

> The feeling of terror is a feeling which serves the purpose of conserving the organism, being initiated by the environment to which the correspondence is indirect, and the agent is known as actively noxious and of overwhelming power, but does not elicit counteraction.

Or, take the definition of *hope:*

> Hope is a feeling which serves the purpose of conserving the organism, being initiated by the environment to which the correspondence is indirect, and the agent is known as actively noxious and of overwhelming power, but is not known with certainty.

A comparison of these two definitions leads us at once to a very clear distinction between the feeling of terror and the feeling of hope, showing that they have most of the elements of feeling in common, but that they differ

solely on the issue of the question of the certainty of the danger from the noxious agent. We can hope only when there is overwhelming danger; and we can hope only when there is uncertainty. In this manner, it is possible to use a classification of this kind to bring out sharply and concretely the distinctions that we desire to make in fixing the connotation of names for feelings.

Exercise. — *Define feelings of (a) fear, (b) hate, (c) annoyance, and (d) disgust in terms of this classification, and point out what the specific basis is for differentiating these.*

Advantages and disadvantages of this classification. — This is a biological classification, objective and concrete, and should enable us to get an adequate classification of all feelings with exact definition of each. But in attempting to apply it, we encounter certain difficulties. First, the names for feelings which come to us from good literature and common usage are a matter of hit and miss or chance survival of terms without reference to scientific relationship or precise definition. The word feeling itself is a notable example, as it is possible to recognize at least twenty-seven different varieties of good usage of the term. It is interesting to compare a definition based on a scheme of this sort with the definition of the same term that you find in a good dictionary. Compare, for example, the character of the information that you get from the above definitions of the feelings of hope and terror with that information which you get by reading the definitions of these feelings in the best dictionary.

It is therefore evident, in the second place, that to make

a psychological classification of this kind adequate and permanent, we would have to scrap traditional usage of terms and construct a consistent, verifiable classification with the corresponding definition of specific feelings. This will probably be done in the near future. It does not seem impossible that the future may see a radical change in our terminology, descriptive of feeling and emotion, in good literature and daily life as a result of the acceptance of some objective and verifiable classification of the feelings somewhat on the order of the above.

CHAPTER XXII

ACTION

In Chapter XIII on Neural Theory we divided the neuro-muscular organism into three parts: the receptors consisting of the sense organs, the central arc consisting of the brain and the spinal cord, and the effectors consisting of the motor neurons and the muscles and glands innervated by them. In the present chapter we shall deal with the effector system, particularly the skeletal muscles and their innervation. From the psychological point of view, this becomes a study of motivation of action.

There are two kinds of muscular tissue in the body: (1) skeletal, striped, or voluntary muscles, and (2) smooth or involuntary. The former are under the control of the central nervous system; the latter, including the glands of internal secretion, are in large part governed by the autonomic system. We shall here be concerned only with the so-called skeletal muscles.

It is convenient to divide action into voluntary and involuntary; although we must remember that there is a gradual transition from one to the other and that, from the neural point of view, the same principles operate in both. There is no rigid classification in which the parts are mutually exclusive; yet, it will be convenient for us to consider in turn some of the well-recognized types, bearing in mind that in a given act several

types of action may be involved, and that they overlap and are not mutually exclusive.

Involuntary Action

Tropisms. — A tropism is a predictable response of animals that have no nervous system, particularly unicellular animals. Thus we have, *e.g.*, heliotropisms, geotropisms, thermotropisms. In a heliotropism the animal turns persistently toward or from light; in geotropism it turns toward the earth, — that is, in the line of gravitation or in the opposite direction; in thermotropism it turns toward heat, or away from heat, as the case may be. Many other forms of tropism are recognized. Here we have the simplest form of animal response or action. The single cell is capable of stimulation and response to specific stimuli, but is not capable of modifying the response. Yet this power of response may be so adapted to the needs of the animal that it is of marked preservative and enhancing value. Such tropisms in animals are but an extension of the same principle so abundantly represented in plants.

It is probable that single cells, or groups of cells, in animals that have a nervous system may respond in the same manner, and that much of our glandular action may be accounted for on some similar principle; but on that point we have no clear knowledge.

Random movements. — Random movements are such movements as are due to general irritation through a nervous system. Most of them are in the nature of reflexes, usually massed so as to lead to apparently aimless movements; such as the earliest activity of the infant in

groping, twitching, grasping, fumbling, reaching, kicking, and gurgling movements — indeed, any form of unorganized action. They are due to the fact that great masses of reflexes, both simple and complex, some cooperating and others conflicting in all possible combinations, are inherited and assert themselves in response to stimuli which impinge upon the sense organs in the absence of organized purpose, adaptation, or meaningful awareness. They are conspicuous, constituting the bulk of action in early infancy; but they are also ever-present throughout life.

EXERCISE. — *Sit "perfectly" still for two minutes and observe what random movements you noted in yourself. Make a full list from "top to toe" in order.*

Of course you did not sit still; you were very active in the form of random movements. The more carefully you observed yourself, the more bewildered you were with the countless twitches that were constantly occurring in your sense organs, in the muscles, in the skin, and in the internal organs.

The significance of random movements lies in the fact that the higher forms of action are developed by the progressive organization of these conflicting and apparently aimless movements into purposive and purposeful action. Thus, from the crude twitching and groping movements develops the power to touch, to grasp, to pull, and similar movements. That is to say, the unorganized masses of reflexes, which we call random movements, may be regarded as the raw material that develops into habits and abilities which serve the purposes of life both consciously and unconsciously.

The simple reflexes. — As we have seen in Chapter XII the simple reflex is the fundamental form of action through a nervous system. We traced there the character and function of some of these reflexes. According to the terminology adopted in Chapter XIII, all the higher forms of modification in the central arc may be described as delayed and conditioned reflexes.

Instinct. — We need here only refer to Chapter XV on instinct, in order to assign instinct its proper place in the list of types of motivation, bearing in mind that instinct is the experience aspect of complex reflexes.

Habit. – Likewise in Chapter XVI, we have already traced the rôle of habit and studied its character as a mode of control of action showing, among other things, the character of the overlapping of habit, instincts, and reflexes.

Imitation. — An act is imitative when it is performed unconsciously as the repetition of the act of another. We must lay emphasis on the unconscious aspect. In common speech, we erroneously use the word imitation with reference to conscious action; as when the teacher says, "Imitate this movement." Here the action called for is not imitative, but deliberate and voluntary, whereas all imitation, psychologically, is unconscious and involuntary. Imitation plays a larger and more dignified rôle in ordinary life than is usually recognized. This fact may be illustrated through an exercise.

EXERCISE. — *Reflect for a while on the topic "The original features in my personality," and make a list of some traits in yourself which you cannot trace to the imitation of others.*

You probably experienced a surprise. Instead of the

request being unreasonable because there are so many traits of that kind, you probably found it difficult to find any examples. You thought of a number of things which are distinctly characteristic of you, and by which your friends recognize you, such as your smile, your hand-shake, your gait, your affectations of speech, your handwriting, your likes and dislikes, your habits and foibles, and laid yourself bare, as it were, to inspection. But, when you dwelt upon one of them intensively, there instantly appeared a sort of family tree of the originals. Take, for example, your own most charming way of saying, "Good morning." Let us say that your friends know this, admire it, and regard it as a distinctive expression of your personality; and you have a feeling that it is done deliberately and heartily. Yet it is quite feasible for you to realize that it can be traced back, in whole or in fragments, to the originals which you have imitated. Say "Good morning" in your most characteristic way and think of it for a moment and you will find that, aside from certain inherited or constitutional capacities and limitations, both the form of your expression and the motivation can be traced as imitation of friends whom you have admired and idealized. You may not have thought of their "good morning," but you have admired *them*, and unconsciously you have taken on from them certain elements expressive of heartiness, responsiveness, reserve, intonation, smiles, gesture, courtesy, and countless other significant factors which together constitute the greeting. You may have gotten one from one person and another from another. Your greeting is a composite of traits in persons whom you

have admired; they have been taken on unconsciously and are daily expressed more or less unconsciously; yet every feature of your greeting has a natural history. This is particularly true of affectations. Such a finding as this is characteristic of how you will discover your indebtedness to others by examination of any of your claims to originality.[1]

This, then, is the fundamental law of imitation: we are consciously and feelingfully aware of persons and things; we unconsciously take an agreeable attitude toward them, and therefore unconsciously tend to become like them.

Consider, for a moment, the rôle of imitation in our cultured lives. In politics there is a tendency for the son to vote as his father has done.[2] In religion, most children, if they join the church, join the one to which their parents belong, and usually with firm convictions that this is the best. That is equally true of Catholic, Protestant, and Jew; and it has biological value. They have come to express their religious life in the forms and ceremonies peculiar to the parental church on this principle of unconscious imitation until that peculiar form of religious expression tends to fit their needs. This is

[1] Many years ago the author tried this exercise and hit upon an odd double loop in his written *y* and *g* as peculiarly his own invention. In attempting to trace the history of it by examination of writing for many years back, he came across the original in a letter from a young lady in which this very loop was conspicuous. It had become a part of his handwriting, not because he admired the loop, but because he admired her. Here is an accessory character of affectation which has expressed itself in his handwriting for forty years, and was long regarded as an original, personal trait of the handwriting.

[2] The author grew up in a community which was overwhelmingly Republican. There was in that precinct only one Democrat and he was a horse thief. Even in mature years, it is necessary for him to struggle against the conviction that there are no good Democrats.

conspicuously true in art. We have schools of art: here and there comes forth a great original; many deliberately do as he did, but the mass of artists have a feeling that they express themselves when they take on the accessory peculiarities of the master whom they admire. This is true even in science, which is supposed to be free from all set and bias. In each and every science there are radical differences of point of view and reaction quite as different as in religion, and it is very interesting to trace each of these "personal" stands back to its origin.

Early childhood furnishes excellent opportunity for the objective study of the growth of character and personality through imitation — imitation not only of human beings, but of animals and inanimate things, for all perception is anthropomorphic. We tend to become like our environment. It is well known that husband and wife tend to become alike. We may even go farther and say parents imitate their children.[1]

Imitation is perhaps the commonest and most useful principle of learning, in that it works in the form of unconscious accumulation of details which become fairly coherent with and adapted to the needs of the growing character. Imitation precedes habit, but the imitative act is perpetuated through habit formation.

Impulse. — Impulsive action is action which results from feeling or emotion. It arises from internal excitation, and there is a gradual transition from approximately simple reflexes up to action which results from strong and persistent feeling. The act is said to be im-

[1] The author has on record a number of cases in which peculiarities of speech and action observed in the laboratory could be traced to imitation of the children who were admired in the home.

pulsive to the extent that the affective element overshadows the cognitive in the motivation. The impulsive act is one which is committed under the stress of strong feeling. The impulse may break out, like a reflex, so quickly that the act can be recognized only in retrospect, as in the case of sudden self-defense; or it may take the form of an uncontrollable disposition, or mood, which leads to a sustained attitude or passion in response to violent outburst. The impulses of attraction are no more effective than the impulses of repulsion; indeed the latter, by virtue of the necessity for prompt action in self-defense, are perhaps most characteristic of impulsive action. The greatest deeds of heroism are done impulsively under the blinding of passion: if the person had stopped to deliberate, he would in many cases have failed. On the other hand, impulse is an all pervading, driving force in all highly efficient and enjoyable behavior. All hearty action has something of the impulsive character. We thus recognize the sway of impulse from its most attenuated affective tone in response to the agreeableness or disagreeableness of the stimulus, up to its most violent outbreak, where the reaction is instinctive and beyond control.

Ideo-motor action. — In the sensori-motor act the occurrence of the stimulation is immediately followed by the response. But many acts are the direct outgrowth of ideas in the mind; *i.e.*, the nerve impulse is of central origin. When the idea is expressed immediately and unconsciously in action, the act is said to be ideo-motor. A child, watching the piston bar of an engine, was observed to move his arm sympathetically with the piston

of the engine and was surprised at the fact when his attention was called to it. Most of our gestures are ideo-motor. Recall a few typical gestures, such as the indication of distance, of approach, of bigness, of littleness, of quickness, of slowness, and it can be readily seen that the gesture activity which often profusely accompanies speech, and even silent thought, will fall under this rubric.

Ideo-motor action differs from imitation in that it pertains to ideas rather than objects or actions. It has been pointed out in the study of crowds, that the ideo-motor action is conspicuous, particularly under great excitement; yet the real significance of ideo-motor action lies not in these oddities of behavior, but in the fact that this principle operates as a supporting principle in all the acts of skill and other forms of effective adjustment. Thus, for example, during the impressive funeral ceremonies for the burial of the unknown soldier at Arlington on Armistice Day, the idea of patriotism found expression consciously in such acts as the lifting of hat and bowing of head, but unconsciously in ideo-motor action in countless adjustments accessory to these and expressive of devotion, reverence, sorrow, sympathy, and praise.

Summary. — These are the prevailing types of involuntary action the mark of which is that the action is not modified by conscious control. Thus, in retrospect, tropisms are movements not mediated through a nervous system; random movements are the over-flow of unorganized and superfluous energy; reflexes are inherited responses; instinctive movements are identi-

fied with complex reflexes; habits are largely adapted reflexes; imitation is the unconscious repetition of the act of another; impulsive action is action precipitated by strong feeling; ideo-motor action is the unconscious, immediate flow of the act from the idea. To the extent that movements are completely involuntary, they are unconscious so far as motivation is concerned: although there may be even profound consciousness of the movement, there is no conscious motivation. But such cases are rare; the normal motivation is a blend of the voluntary and involuntary.

Nor is an act ordinarily of one type alone: a given complex movement may involve all types at once. Such is the act of self-defense. This act is ideo-motor in that the idea of danger runs unreflectively into the defense; it is impulsive in that this idea is highly emotional on account of the danger to life; it is imitative and habitual to the extent that the individual has acquired defense habits by practice and emulation of others; all defense reactions are instinctive and reflex; all large movements carry an overflow of random movements; and in such organic explosions there is undoubtedly glandular activity of the tropism type. Yet, for the purpose of description and explanation, all these types are significant and essential because each tells its own story.

Voluntary Action

Action is said to be voluntary to the extent that it is delayed and controlled consciously. This statement does not imply that consciousness, as distinguished from neural

activity, initiates or modifies action; but rather that action is modified by such psychophysical processes as we recognize in terms of consciousness. It might equally well be designated in terms of neural pattern or process if we had the power of description and appreciation in such terms. As we have seen, there is normally a mingling of the voluntary and involuntary patterns of action in waking life. Even the purest form of voluntary action involves the operation of complex patterns of involuntary action; and most forms generally classified as involuntary tend to be modified directly or indirectly by voluntary efforts. Psychologically, the primary condition of voluntary action is the hesitation or delay that gives opportunity for the operation of desire, deliberation, and choice, which are the main stages in volition.

Desire. — Desire is feeling in the aspect of swaying action. It may arise at any mental level. There are, *e.g.*, sensuous desires, imaginal desires, rational desires, ideal or sentimental desires, and impulsive desires. In every case there is an object in mind, not immediately realized, but tinged with feelings of attraction. Such are the appetites for food, drink, and sex; the longing for things remembered, such as home, or things imagined, such as success; the yearning for peace; the craving for truth, goodness, and beauty; the passion for revenge, each representing a feelingful attitude toward a goal.

The companion attitude to desire is aversion. The psychology of the two is the same, or parallel. But desire occurs with reference to goals which are regarded as beneficent for the organism, whereas aversion occurs

with reference to those that are regarded as noxious to the organism. As in the case of emotion in general, there may be conflicts of desire and aversion arrayed in rapid shifts of attitude toward a complex goal.

"Now, if we pass in review the various things which we seriously wish for ourselves, we shall find that the vividness of the desire is proportional to the extent to which some one or more of our rudimentary impulses and emotions are enlisted. Objects which do not appeal to any of these primary instinctive reactions do not call forth intense desire. At most, we sporadically 'wish' for such things. But the wishing is of a relatively cold-blooded, incidental kind, utterly distinct from the hot, passionate, craving which we feel for objects of the first class. . . . The experiences in which we are conscious of the definite yearning of desire, or the positive distaste of aversion, are, therefore, those which directly or indirectly call into activity such impulses as play, love, sympathy, grief, ambition, vanity, pride, jealousy, envy, fear, and hate. Without these or their congeners to color the occasion we rarely meet with anything which we could justly call either desire or aversion. . . . Desire gains its power and vivacity from its impulsive nature; it gains its rationality from experience. After our emotions and instincts have been once expressed, we know in the future what to expect of them. Desire is the conscious condition which represents this knowledge of what an emotional impulse means. It is the craving unrest for the object which we know will give us pleasurable satisfaction." (Angell)

In the voluntary act this desire or aversion may be of various degrees of compelling force from the attenuated affective state to the most intense emotional impulse. At one extreme it is relatively inconsequent; at the other

it may run into action which is impulsive to the extent that it does not permit of deliberation.

These desires and aversions may be specific and near of attainment, as in the appetite for food and its prompt satisfaction; they may be remote and generic, as in the desire for truth which is the commonest motive in deliberation, or the aversion for suffering which is another conspicuous motive. A given situation may involve both the specific and the generic, as in the craving for the day's wages as a specific object, and the general craving for fairness and the necessities of life.

Deliberation. — The main characteristic of deliberation is the act of planning which, however much it may be abbreviated and telescoped, is a form of thinking preceded by the affective attitude which we have described as desire or aversion and followed by the mental action known as decision or choice which, in turn, may precipitate or inhibit the muscular movement. In this planning, there must be, first, the consciousness of an end or object to be attained. The conscious object is usually tinged with the feeling of desire or aversion out of which it grew in the normal process of association. There follows immediately consciousness of various means of attaining or avoiding this end; and the planning consists essentially in the weighing of these means as a preparation for choice, or the movement of selective attention in a series of judgments.

Choice. — As in reasoning in general, the tipping of the balance, after weighing a series of judgments, results in a decision or choice with the feeling "let go." On the subjective side, this denotes a state of convic-

tion or satisfaction or "acceptance of sufficient reason" for action.

Movement. — The final act in reasoning is the naming of the conclusion whether it be merely conceived in thought or expressed in any form of language. The corresponding act in the voluntary action is the bodily movement which takes the place of the conclusion. Thus, the process of voluntary action is identical with the act of reasoning except in the form of expression: in pure reasoning the expression takes the form of a final concept or accepted truth, whereas the choice in voluntary action is realized in bodily movement. From this point of view reasoning is a voluntary act, and we may recognize two kinds of voluntary action: that which terminates in a mental act (reasoning), and that which terminates in a bodily movement (voluntary movement).

Volition. — In the old psychology it was assumed that will, which we here call volition, was the assertion of a sort of outside force or personal power which modified the stream of consciousness. In opposition to this view, we conceive of volition as a sort of self-determination or self-assertion of the basic character of the psychophysical organism itself. In volition the organism as a whole is at work in all its aspects. There is impression, association, recall, recognition, imagination, reasoning, feeling, impulse, — all more or less conspicuous in attentive consciousness. Volition is, then, not a faculty but a form of the organism as a whole at work.

As a substitute for the old concept of will, we often find selective attention clothed in the paraphernalia of scientific psychology but in essence the stalking of the

old spirit-will in the garb of attention. To guard against this fallacy, we must recall that attention is not regarded as a force or process in itself. If this is kept clear, the psychology of volition may well be described in terms of the movement of the focus of attention. Indeed, this is the modern account of volition.

The voluntary character of the act cannot be judged in terms of length of the delay. The deliberation may take place in a sort of lightning fashion in volition as in thinking. To put in evidence a homely example: in the good old bicycle days, I was coasting with a bundle of books under the arm and the wheel slipped into a rut which resulted in an instantaneous fall. Yet, in the fraction of a second there was extended deliberation: "Shall I risk the books or my limbs? Some of the books are not mine; they belong to the library. Is that a reason for protecting them? How much risk am I taking? Which of the available modes of alighting shall I follow? Well, here goes!" All this and more flashed through the mind in the time it took the wheel to topple. This deliberation was quick under stress. But the best forms of effective deliberation are quick as a result of acquired skill in telescoping the component processes.

Nor is action voluntary merely because it is delayed. Delay may be and often is merely the occasion for confusion, incoherence, and inhibition with corresponding movement. Delay is essential, but the shortening of the delay without loss of efficiency in deliberation is a mark of mental development and power. The person

with well-developed will power makes quick decisions with apparent ease.

Inhibition. — We have spoken so far of voluntary action on the positive side. But there is an equally important negative. It is often as difficult and as important to keep from acting as it is to act. This ability to prevent the impulse from running into action, whether mental or physical, we call inhibition. The power of inhibition is one of the higher marks of well-developed character. The child's impressions tend to run immediately into action; but mental development is the building up of the power of inhibition which is the central factor in self-control. Judicious power of inhibition is the mark of mental development, health, and sanity.

EXERCISE. — *Rise, walk ten feet forward, turn, and return to your seat. Write a terse one hundred word account of this voluntary act in strict psychological terminology.*

THE BASIC VOLUNTARY MOTOR CAPACITIES

For the purpose of experimental psychology, we may analyze voluntary bodily movements into a series of basic motor capacities, on the same principle that we analyzed the fundamental knowing process into a series of sensory and intellectual capacities. The following table offers a serviceable classification:

A. *Time of Movement*	B. *Precision of Movement*	C. *Energy of Movement*
1. Motility	1. Direction	1. Strength
2. Simple reaction	2. Distance	2. Endurance
3. Complex reaction	3. Force	
4. Serial action	4. Form	
5. Timed action	5. Pursuit	
6. Rhythmic action		

We daily classify persons for practical purposes as quick and accurate, slow and inaccurate, slow and accurate, quick and inaccurate, with fine gradations among these differences. Such distinctions apply to all the skeletal muscles, and it is possible to determine a sort of "personal equation" for the individual; *e.g.*, if he is quick and precise in the movement of his hand, we may with reasonable certainty look for the same characteristic in the movement of his wrist, arm, and shoulder; knee, foot, and toe; head, eyes, and tongue. In other words, there is indication that he has a good central control affecting all these muscles. To this rule there are, however, some notable exceptions in the form of uneven development.

Motor capacity is measured in terms of two factors: (1) achievement, and (2) variability. Achievement is usually measured in terms of the average record made under the most favorable circumstances, and variability is measured in terms of the mean variation in a series of successful trials. Since variability is a negative quality, we use its reciprocal, accuracy, to denote such factors as uniformity, reliability, and predictability, which are the reciprocal of variability.

Motility. — Speed and accuracy in mere voluntary movement are best measured in the simplest, unskilled movement that we can perform continuously with a maximum voluntary effort. Some form of simple tapping may answer the purpose.

EXERCISE. — *Draw a circle about 2 inches in diameter. Seated in the most favorable position, tap with your pencil inside of this circle as fast as you possibly can for 5 seconds, scattering the dots within*

the circle. Use the simplest and smallest movement. Make ten trials. Count the dots in each circle. Find the average and the mean variation.

In this exercise you realized the importance of control of conditions, such as the attitude of bodily tension and favorable position, minimum distance and simplest form of movement, holding of the pencil, effort, emulation, direction of attention, readiness, favorable disposition, physical condition, and many other factors. In the laboratory, we measure motility with accurate instruments in which we control the extent and the direction of movement and measure the duration of each movement in hundredths or thousandths of a second. This crude test, however, illustrates the principle of measurement. A very slow person may not be able to make more than twenty taps per second, whereas a very quick person may make as many as fifty-five. In technical measurement of an individual, such records are given further significance by quantitative norms showing the relation of this capacity in tapping to capacity in the movement of each and every other significant muscle in the body, and of the relation of this capacity for movement to higher forms of voluntary movement. When the same thing is done for each of the other measurements indicated in our classification, we shall have a quantitative profile in the form of a chart which will give, at a glance, a picture of the voluntary motor capacities of this individual, showing his degree of excellence both as to speed and accuracy in each type of movement as depending upon the kind of mental activity which is required in motivating the movement.

Space here permits only a bare mention of the measurements in the other capacities.

Motility measures the speed and variability of mere movement, repeated as fast as possible, without any demand upon the higher mental capacities. In simple reaction, we measure the time of a single response to a specific stimulus. This requires perception and response. In complex reaction, we may introduce a series of higher mental processes in turn, such as discrimination, choice, judgment, and association. In such cases the reaction and the change of time is ascribed to the additional mental processes, such as discrimination-time, judgment-time, and association-time. Thus, in complex reaction, we measure really not the time of the response itself, but the time of the mental processes which condition the response.

Simple reaction. — In simple reaction-time we measure the time that it takes to respond with the simplest movement to a clear and simple stimulus in any of the senses, such as color, light, sound, contact, odor, or pain. The reaction-time varies with the sense stimulus, the individual, and a number of objective and subjective factors which are more or less under control. The reaction to a sound may be made in ten hundredths of a second; whereas the reaction to an odor or a taste is very much longer. Very large individual differences exist.

Complex reaction. — In complex reaction we imitate the conditions of the reactions in ordinary life by selecting a typical situation which can be controlled. Thus we may have, *e.g.*,

(*a*) *Reaction after discrimination.* — To illustrate in color, the observer is told that he will see either a red or a blue color, and to react as soon as he knows whether it is red or blue. In this case the added feature is the necessity of discrimination.

(*b*) *Choice.* — In this case the observer is told that the stimulus will be red or blue and to react if it is red but to remain inactive if it is blue. The new element here added is that of choice or decision to react or not to react; and this takes time.

(*c*) *Association.* — In this case the stimulus may be a word, *e.g.*, "high," and the instructions are to react by speaking the word which denotes its opposite ("low"). Here the new element is the restricted association, — the necessity of thinking of the word for the opposite.

(*d*) *Memory.* — Here the stimulus may be, for example, the name of a city, and the response is to be the speaking of the name of the state in which this city is located.

(*e*) *Judgment.* — The stimulus consists of a situation which requires a judgment, and the reaction may consist of the speaking of the word "yes" or "no."

Serial action. — Capacity for serial action may be tested at any of the reaction-time levels by so arranging the situation that each response brings up the next stimulus automatically, and the observer is required to respond in a chain of reactions, without interruption, in a manner analogous to the tapping in motility. In this manner, any of the forms of complex reaction may be required in a continuous series so that we test the power of application at that level of mental activity.

Timed action. — In timed action there is a regular stimulus, such as the tick of a clock, and the observer is required to mark time in exact step with the stimulus or he is required to execute a continuous movement at a fixed rate. Measurement is made in terms of average deviation from the true time.

Rhythmic action. — This is like timed action except that rhythmic patterns are required, and these may be made of various degrees of complexity.

This list of types of action time is fairly inclusive, so that all forms of response may be regarded as typified by one or more of these in various degrees of refinement. If we know a person's capacity in any one of these, we can immediately apply it to the whole class of actions which it represents. For example, if a person should rank, say 95, in rhythmic action in this test, that would lead us to expect him to be highly rhythmical in executing all movements adapted for rhythmic grouping.

Precision. — Movements may be divided into a small number of classes as regards precision as well as on the basis of time:

(*a*) *Direction.* — Capacity for precision in direction of movement is usually tested in terms of the precision with which the observer can hit a sort of bull's-eye with a pointer in a free-hand lunge. This test is usually made with the right hand, but, as in the case of motility and reaction, it may be made with any limb of the body.

(*b*) *Distance.* — Measurement of this capacity is analogous to that of direction. The observer is required to make a lunge with the hand to a certain distance and the average error is determined.

(*c*) *Force.* — The measurement of this may be illustrated with a spring letter balance. The accuracy with which the observer can repeat a standard pressure, guided by the kinæsthetic sensations, gives a serviceable measure.

(*d*) *Form.* — The commonplace test of this is, of course, in writing and drawing; but exact laboratory measurements may be made for simpler movements under accurate control of conditions.

(*e*) *Pursuit.* — This is the most complex form of precision; it may be illustrated by having an electric contact, the size of a dime, near the periphery of a revolving phonograph plate and requiring the observer to keep a contact point on this plate through forearm movement while the plate is moving at the rate of one revolution per second. The observer there has to control the direction, form, and time of the movement in coördination.

Energy. — The two chief variables are strength and endurance.

(*a*) *Strength.* — The simplest measure of this is the strength of a grip or a pull. One person has a vigorous physique with strong muscles; another is feeble. There are established norms of strength for different ages, for sex, and for other type variables.

(*b*) *Endurance.* — Endurance is tested by what is known as an ergograph in which a person is required, for example, to make the strongest grip or pull that he possibly can make, and to repeat this continually for a given time. An accurate record of the achievement is called an ergogram. The measure of endurance becomes also a measure of fatigue.

Particularly noteworthy in measurements of this kind are the magnitude and fixity of individual differences in a given capacity. One individual in a group of so-called normal individuals may have many times the capacity of another. For motility the range of difference is small because it is a simple act. In the more complex forms, one individual may have ten or twenty times the capacity of another.

The character of an individual, so far as the natural capacity is concerned, is analyzed by these measurements so that in a chart of them one can see at a glance the rank of the individual in each of the types of motivation of action represented.

All measurements may be represented in terms of rank. It may be assumed that the physical movement of response is the same or equivalent in all cases. The differences which are measured are, therefore, the differences in capacity for mental activity. One person may be strong on sensation, another on memory, another on judgment, or some other factor. It is self-evident that this is of very far-reaching significance for the valuation of an individual's fitness for action in trades, arts, and other occupations in which speed and accuracy of action are significant.

Some of these capacities involve the possession of special talents, such as the reasoning power, sense of time, and the sense of rhythm. All together furnish an index of general motor control in time, precision, variability, and energy of action.

CHAPTER XXIII

DREAMS

One-third of our life is spent in sleep — dreams. Instead of regarding the dream as abnormal, queer, fantastic, occasional, unreal, chaotic, and unexplainable, we shall study it as a natural phenomenon, not only for its own acquaintance, but also for the light it throws upon waking life; for dreams furnish us one of the best illustrations of the nature and rôle of subconscious mental processes.

Predisposing causes. — We have learned that there is a cause for every memory, thought, feeling, — every flitting image in consciousness. The same is true about the subconscious of which the dream is a part: every flitting dream image, even every dream blur, flows from some cause and has specific relations with the rest of the mental life.

Disturbing dreams occur when the nervous system is in an irritable and unstable condition; unrest results in dreams. This predisposing cause of dreaming may be chronic or temporary. Some persons have such a nervous disposition that they never rest well, and all persons are guilty of indiscretions which leave them to do penance in dreamland. The second piece of mince pie, ice cream, hot coffee just before leaving the evening party, physical over-exertion, mental over-exertion — in short, count up the sins against your mind and the sins

against your body and you will have named the predisposing causes of the disturbing dreams of restlessness. But, as we shall see, the vast body of dream life is a normal part of restful sleep.

Presentative dreams. — Dreams may be presentative or representative in origin. The presentative are caused by sense stimuli, such as light, sound, odor, taste, impact, heat, cold, and pressure. The following experiments made by Alfred Maury in illustration of presentative dreams may be quoted:

"*First Experiment.* — He caused himself to be tickled with a feather on the lips and inside of the nostrils. He dreamed that he was subjected to a horrible punishment. A mask of pitch was applied to his face, and then roughly torn off, taking with it the skin of his lips, nose and face.

"*Second Experiment.* — A pair of tweezers was held at a little distance from his ear, and struck with a pair of scissors. He dreamed that he heard the ringing of bells; this was soon converted into the tocsin and this suggested the days of June, 1848.

"*Third Experiment.* — A bottle of eau de Cologne was held to his nose. He dreamed that he was in a perfumer's shop. This excited visions of the East, and he dreamed that he was in Cairo in the shop of Jean Marie Farina. Many surprising adventures occurred to him there, the details of which were forgotten.

"*Fourth Experiment.* — A burning lucifer match was held close to his nostrils. He dreamed that he was at sea (the wind was blowing in through the window), and that the magazine of the vessel blew up.

"*Fifth Experiment.* — He was slightly pinched on the nape of the neck. He dreamed that a blister was applied, and this recalled the memory of a physician who had treated him in infancy.

"*Sixth Experiment.* — A piece of red-hot iron was held close enough to him to communicate a slight sensation of heat. He dreamed that robbers had got into the house, and were forcing the inmates, by putting their feet to the fire, to reveal where their money was.

"*Seventh Experiment.* — The word Leonore was spoken. On awaking, he recollected this word, and found that he had attributed it to one of the persons who had conversed with him in his dream.

"*Eighth Experiment.* — A drop of water was allowed to fall on his forehead. He dreamed that he was in Italy, that he was very warm, and that he was drinking the wine of Orvieto.

"*Ninth Experiment.* — A light, surrounded with a piece of red paper, was repeatedly placed before his eyes. He dreamed of a tempest and lightning, which suggested the remembrance of a storm he had encountered in the English Channel in going from Merlaix to Havre."

In each of these experiments the dream could be reproduced because the dreamer was awakened in the very act. Had he been allowed to sleep until morning, there would have been but little likelihood of the recalling of the dream. The significant fact is that, allowing for the realism and the dramatic form of the dreams, experimental procedure confirms the theory that every sense impression tends to produce a corresponding dream.

The senses are open in sleep even under the most ideal sleeping conditions. Sense impressions are playing upon our sensorium continually during the night. Certain sense stimuli, such as the retinal lights, taste in the mouth, excessive temperature, pressure and pain caused by contact with the bed clothes are conspicuously present during sleep. A very large portion of dream life comes

through sensory experience. Stimuli which are suppressed during waking life are given free sway in sleep and the possibilities for varied dream modulations are notoriously great.

Representative dreams. — The representative dreams arise in the same manner as memories, imaginations, or feelings, in waking life, in accordance with the laws of association. They may be regarded as free associations. Usually they are the indirect result of sensory impressions, which serve as starting points for changes of association: for example, as your ear registers the trickling of raindrops, you do not dream that it rains, but a train of images flashes into your mind, — successive scenes and pictures of rain, waiting in the rain, suffering of the poverty stricken, philanthropy, hunger, all in realistic and dramatic action. The case of reverie illustrates the process: you recline in a comfortable position and relax your attention, so that mental images pass before you in a series, unchecked. It is possible to go back over the series and give account of each successive step.

The themes or motifs are usually determined by dominant interests; for example, an examination, a love affair, some sport, business venture, fear, or ambition. There are two distinct tendencies: one, to continue the activities of the day; the other, to live the instinctive and racial traits which have not found expression during the day.

Frequency of Dreams

Is there any dreamless sleep? I venture the assertion that probably all persons dream all the time when

they are asleep (and sometimes when they are awake). There is probably no dreamless sleep. But on this moot question authorities differ. Let us couch a part of our description of the dream process in an argument on one side of this question. Such grounds may be seen in four directions: the observation that inability to recall a dream is no proof of the non-existence of the dream, certain theoretical considerations, experimental proof, and spontaneous expression of dreams. Many other lines of evidence might also be brought to bear. The proof must necessarily be inductive, and therefore can be only cumulative; the most that we can prove is a high degree of probability of the truth of the proposition.

The memory evidence. — The notion that dream consciousness is not continuous in sleep rests essentially upon the memory test, the feeling that, since we recall dreams only occasionally, we have had only occasional dreams. Replies to questions as to the frequency of dreams run somewhat like this: "Very much every night"; "Nearly every night"; "A dozen times a month"; "Hardly ever"; "Never." But such reports tell us nothing about the frequency of dreaming, for they refer only to the frequency with which dreams are remembered; and we know now that normally dreams are not remembered. Only the exceptional dream is remembered. If one has had a hundred dreams during the night, he may or may not remember one or more of them. Whether or not a dream may be remembered depends upon its coherence, the strength of associational ties, the depth of sleep, the habit of re-

calling dreams, and many other similar conditions. As a rule, dreams are not remembered; mental development and efficiency in waking life are conditioned upon our freedom from the burden of consciousness of the massive apparent chaos of dream life.

We remember only those experiences which are coherent, clear, and rational — experiences that are more or less individual and have meaning with reference to waking life. The vast mass of dreams are too fragmentary, too fleeting, too much thrust upon us as an undifferentiated jumble — in short, too meaningless to be remembered. Of the dreams which have meaning, we remember only those that are recent, primary, and strong, and stand in striking congruity or incongruity with our dominant feelings. Most of the coherent dreams are wanting in these respects and are only distantly relevant to waking consciousness. Of the relevant and coherent dreams, we recall only those for which situations in waking life chance to occur in such a way as to establish bonds of association that shall extricate them from the mass of unrecognized dream traces. You wake up in the morning after a sound sleep and may not be able to recall any dream; but, the moment you stoop to lace your shoe, a vivid dream image flashes up and you recall that you dreamed in the night of walking barefoot in the snow. Had there been no notice of the shoe, this dream of the want of a shoe might not have been remembered. On the whole, there is slight chance that situations in waking life shall so occur as to elicit the image of a dream which is sufficiently recent.

Even with all other considerations favorable, the abil-

ity to remember a dream is conditioned upon the presence of a habit of recalling dreams. The development of such a habit is on the whole undesirable; should a person remember all his dreams, he would lose his mind and be helpless; therefore, the principle of natural selection tends to suppress dreams. The author, like many other students of dreams, has found it advisable to abandon the intensive study of dreams because habits of observing and recalling dreams interfered with normal sleep.

The dreams which we remember come from light or disturbed sleep. The failure to remember dreams is roughly proportional to the depth of sleep. The depth of sleep can be measured by psychological experiment in terms of the strength of the stimulus necessary to awaken the sleeper at fixed intervals in the night. The normal curve for depth of sleep shows that our profound sleep occurs during the first two hours of the night; after that the sleep is comparatively light. Now, it is the rule that the lighter the sleep the more likely it is that the dream will be remembered. As a rule, the dreams that we remember occur in the light sleep of the morning hours. The frequency of remembered dreams may, therefore, be fairly represented as inversely proportional to the depth of sleep.

There are great individual variations both in regard to the amount of dreaming and the number of dreams remembered. Thus, dreams differ with age, both in number and kind. The child dreams most; the adult has a smaller number but a greater coherence of dreams; the very old person dreams but little. Women dream

more than men. Women get less fresh air than men; they are usually more frail; they are in the house more, and therefore have more contact with situations which cause and recall dreams. Dreams increase with intelligence. Savages dream comparatively little. The greater the strain on a man's nervous system the more he will dream. Certain diseases have characteristic dreams. For example, consumption, hysteria, kidney troubles. Some bodily effect of the disease becomes the starting point of the dream. Dreams also vary with the season, the conditions of sleep, the length of sleep, the degree of exhaustion, atmospheric pressure, and many similar conditions.

Sleep-walking occurs only in deep sleep. Many apparently fabulous stories of feats in sleep-walking are found true. A college student formed the habit of getting up in sleep, dressing, walking down to the Mississippi River three-quarters of a mile distant, undressing, taking a deliberate and enjoyable swim, dressing, walking back to his room, undressing, and retiring, only to wake up in the morning without the slightest inkling of remembrance from the escapade of the night. But when his friends constituted themselves detectives and awakened him suddenly in the act, the whole performance stood out clear to him in his memory. Sleep-walking is dream-action. If a sleep-walker is allowed to return to bed without being awakened, he will have no memory of the dream action in the morning.

In deep sleep we may do anything we could do in waking life, and even more, for the dreamer may become a distinct second personality, free from some of the

limitations of the waking personality. Thus we have in dream-action evidences of the most amazing complexity in the deepest undercurrents of mental life, under the very conditions which preclude the possibility of memory of the dream. In view of such considerations, it is clear that, from the negative point of view, arguments for dreamless sleep on the basis of the memory test can have no valid foundation.

Theoretical evidence. — Turning then to our theoretical proof, we find a strong argument in the generally recognized correlation of mental activity with certain neural activities. There are many theories of this relationship, but for the present purpose we need not assume that this correlation is complete; nor need we inquire into the nature of the causal relations; the fact that there is an observable correspondence is enough. We know from physiology that no part of the nervous system is ever wholly at rest. It is difficult to conceive of any condition in which the flux of sense impressions should be absent. All these sense impressions in sleep cause dreams; the central association mechanism is constantly at work weaving an intricate network of relationships among these impressions, thereby giving them meaning, however far-fetched. Indeed, the very closing of the eye as in sleep is conducive to an increased play of visual impressions, for the internal stimulation gives rise to the so-called retinal light, "the stuff that dreams are made of," which may be very brilliant and is always seen in a more or less gorgeous kaleidoscopic motion.

Stimuli through the ear, nose, skin, muscle, and even

the closed eye, affect the mental organism on the same principle as in waking life. Internal stimuli act not only upon the sense organs but also directly upon the brain and other nerve centers. Pressure caused by the rush of blood, metabolism, and other chemical stimuli arouse nerve impulses. Probably chemical, thermal, and electrical action within the body tissue may stimulate nerve elements directly. Theoretically, such centrally aroused nerve impulses have their mental correlates. On the theory of concomitance, we must therefore assume that there is a continuous stream of mental processes which corresponds more or less to the continuous activity of the nervous system. In sleep such mental processes are subliminal; *i.e.*, subconscious: they are dreams.

In short, on the theory of correspondence between certain mental and neural processes, the continuous impressionability of the senses and the constant stimulation within the central system itself point to an uninterrupted dream activity in sleep.

Experimental evidence. — It is possible to enter into conversation with a sleeping person; and, if the sleeper is not awakened at the time, he is not likely to remember anything about it. The replies are proof that the apparently dreamless sleeper hears the conversation, understands it, and fits his words to the ideas in mind. It is claimed that talking to a sleeping person is an effective way of instilling ideas which it is desired should work themselves out in the waking state. The method has been employed in the breaking up of bad habits and in the effort to create desirable habits. Hypnosis may be

employed to bring out evidence of dreams from apparently dreamless sleep. If a person wakes up after an apparently dreamless sleep, he may be hypnotized and given the suggestion to recall dreams from that sleep. There is such a kinship between the dream state and the hypnotic state that it is quite possible to conjure up in the latter the experiences of the former. The report of such dreams may be checked and verified, in part at least, by controlling conditions for production of dreams experimentally in the sleep, and then checking up the hypnotic report by these known causes of dreams. Waking suggestion may be employed, some think, even more effectively.

By the method of psychoanalysis the dreamer is put through a sort of sweat-box process, not necessarily unpleasant, in which the inquisitor, following clues progressively revealed, discovers motives which step by step lead to the effective associations that may recall to memory dreams not otherwise recallable.

The experimental evidence, then, tends to prove that dreams are caused by natural stimuli as sensations are caused in waking life; given a sense stimulus, we may expect a dream to follow. The fact that a dreamer may carry on a dream conversation, or be influenced to modify habits by suggestion in sleep, is proof of highly complex and rationalized activity in sleep, of which the dream carries no trace into waking consciousness. The evidence through psychoanalysis is illuminating. The experiments with hypnotic suggestion and waking suggestion add convincing evidence to the belief that, whenever we have adequate means for the testing of

a given moment of sleep, we find it occupied with dreams.

Spontaneous expression. — The theoretical conviction thus strengthened by experimental tests is further fortified by close observation of spontaneous expressions of dreams. It is a law of psychology that what is in the mind tends to express itself in appropriate action, even though only inceptive and normally only faint. A skilled observer watching a sleeping person may be able to observe uninterrupted evidence not only of a continuous stream of dreams, but also of rich complexes of dream conflicts. If this observation be done with the expert skill of a so-called mind reader, most marvelous reports may be drawn from dream life through the unconscious reactions, especially the rich play of facial expression, which is eloquent language. If the observer also "reads" the environment with the same skill, and associates the continuous flow of sense stimuli with the psychophysical expression, his observations are reduced almost to experimental control.

Waking dreams. — It may be said that these contentions prove too much in that they prove the presence of dream consciousness in the waking state. That is granted, and it is an important fact. We dream a great deal on the ordinary rounds of duty. One who is trained in psychological observation of dreams will catch himself frequently in moments of dream consciousness, sometimes infinitesimally short, and in the midst of mental application. The author has observed dream flashes in his own mind, even while lecturing before a large audience.

The subconscious impressions in waking hours have much in common with dreams. There is in all our conscious life a rich encircling fringe of free association; but we have acquired the valuable power of keeping this "fleeting show" subliminal because that is conducive to sanity and mental efficiency. When you attempt to observe it for the first time, you find yourself in the position of one who, at a glance, notices but a few stars and attempts to count them; the more he tries to count, the more the field of vision tends to fill up with the countless. From this point of view the dream is a chaos only in the same sense that the mass of stars are a chaos. Both are organized, the stars a macrocosm, the dream a microcosm.

The more absent-minded we are, the more coherent and prolonged these free associations become. The step from absent-mindedness to light sleep is in the same direction and is no larger than the step from active attention to absent-mindedness. These free associations constitute our dreams. Free from the limitations which operate in waking life, free even from the bounds of waking imagination, free association holds full sway and winged fantasy is at her best. Dream fantasy has moving pictures outdone, for the prevailing dream type is that of the flash-picture or snap-shot, and sleep affords the best condition for richness of setting and rapid change of scene. How little of this rich dream life we actually remember may be realized if we consider that a dream, which in the recall may be represented as lasting an hour, may be but the conscious elaboration of what in the actual dream was merely an instantaneous flash image.

The theory of dreamless sleep came into vogue at a time when man held a crude and all too simple view of the mind. Experimental psychology has deepened insight and broadened our view of mental life, ever revealing more and more aspects before unobserved. Only a few years ago, it was thought that to have an illusion or an hallucination was of necessity to show mental weakness. Hallucinations and illusions were therefore supposed to be rare objects of curiosity. Now we know that hallucinations and illusions are normal and ever-present in all well-regulated mental life. It has been shown that the conditions which cause illusions and hallucinations are as a rule fundamental and essential conditions of normal mental power. The very principle which enables us to see true perspective in one situation leads of necessity to illusion in many other situations. Now, the man who asserts that his friend has been subject to an illusion, as if he himself were exempt, is the man who asserts that he dreams only occasionally. It may be safely maintained that the authorities who defend the theory of dreamless sleep espoused this theory before the recent notable advances in our scientific knowledge in psychology of cognition were made. The more we study dream life in the light of scientific method in psychology, the more the idea of the ever-presence of the dream in sleep grows upon us, not as a result of more and more observed cases only, but rather as a logical inference from growing knowledge of the operation of mental law.

The arguments advanced in support of the continuity of dream life imply and lead to certain interpretations

of the nature of the dream, which give it a true setting in an evolutionary and naturalistic conception of the mind and give us a deeper insight into the actual richness and significance of dream life.

Characteristics of Dream Life

As it will be impossible in this brief chapter to describe dream types, to discuss the various types of explanation, or to consider the various problems of dream interpretation, we shall limit ourselves to the enumeration of some of the prominent traits of dream consciousness.

Subconscious. — The dream is a perfect example of the subconscious mental process, in that it is disassociated from the waking consciousness of self to the extent that the dreamer is not aware of himself as dreaming and cannot control his dreams.[1]

Illusion. — All dream life is in the present; hence, in the form of perceptions and images. The dream avoids the abstract, even verbal report, and employs mental pictures of dramatic realism. Instead of remembering or imagining a childhood scene you find yourself enacting it. It comes in not as a memory, imagination, or thought, but as a first and present experience. From the point of view of dream consciousness, the dream is a perfect illusion, in that it is a sense presentation which does violence to the sensory data when present, but has all the

[1] "Dreaming becomes representative of the subconscious form of mental procedure because the mind is therein dependent upon inner resources, is freed from the watchfulness of self-observation, takes no heed of the channels through which material is borne, has no world of reality to impose upon it the binding regulations of what is possible, right, or commendable; has no goal to reach, but only a playful purpose to serve; and so may wander far afield, as does the waking mind in the recreation of its idle musings." (Jastrow)

elements of a clear and convincing perception. Not only may the central dream object be clear; but, on account of the fact that the span of the subconscious is much greater than the span of the conscious, an extraordinary richness of detail of background and setting is present.

Dramatic. — The dream is dramatic: it is living action in the present, realistic and free from the limitations of reality. In the dream of your childhood days you are right there in a concrete situation, playing your old-time part in a real place, with real objects and playmates around, regardless of the limitations of time and space. The dream makes use of all the forms of dramatic license. Anachronisms do not jar. You are carried passively as in a state of fascination, or at the mercy of great powers. You are the chief actor, or at least an active observer. The dramatic effect is so complete that you do not doubt the reality of the situation. Hence the dream may possess the powers and charms of the drama to a degree which is never attainable in waking life.

Symbolical. — The more intimately we penetrate into our dream life, the more we realize that the dream is symbolical. This again is merely the extension of the principle of free association. Even abstract ideas, such as truth, purity, and beauty, are pictured in rich trains of extravagant images, all relevant; often the relevance is the more astonishing as the relation is far fetched. The recognition of this principle of symbolism is fundamental in dream interpretation through psychoanalysis.

Exaggeration. — It follows that dream life is a process of gross exaggeration. It would be truer to say that it is

the exaggerated dreams that we remember. Those that are not exaggerated are too common and too frequent to be observed and remembered. Yet the dream does exaggerate. When a reflection of the moon strikes upon your closed eyelids, you do not dream that, but in your dramatic and exaggerated fashion you dream that you are in a tropical climate, living in a scene of gorgeous light and life.

Violation of time, space, and causality. — The dream is an image or group of images appearing in accordance with the laws of association. In the absence of the waking "censor," self-control, these images are free, independent of the three limitations which make experience consistent — the laws of time, space, and causality. These concepts all operate in a dream but with dream license; one of the charms of dream life is its freedom in the sense of abandon — the disregard for time, space, and energy. As regards time, the dramatic license of the dream makes everything present, whether it is taken from the past, present, the future, or the non-existent. As regards space, miles, continents, oceans, cut no figure; everything must be in the plot, and the plot is where you are. The gates of death offer no obstruction, for our departed loved ones comfort us with a sense of their real presence in our dreams. We do not hesitate to claim new powers, such as the ability to fly, to pass instantly from one continent to another, to transcend the bounds of death, to communicate with the gods.

However, certain dreams, such as bogey dreams, present just the opposite state of affairs. The dreamer feels deprived of all energy, helpless, and lost. But this unnatural

feeling of restriction also falls under the principle of disregard for time, space, and energy.

Flash-like. — Dreams do not take the same time as waking mental processes do. Many are flash-like and of a fragmentary order. You can dream in a second what it may take half an hour to recount in memory. Most people have had such experience with the slam of a door or the touch of a falling object; that the same thing which gave rise to the dream also awakened the sleeper, and a long dream was completed before the awakening. The dream is like a flash-light picture. There is an instantaneous view of a familiar situation and this is elaborated in the reproduction. This trait is characteristic of the prolonged dream as in a many-hour struggle to solve a problem or to extract yourself from a difficult situation. What happens is that the same scene or succession of scenes is repeatedly flashed into view in a sort of vicious circle, if bad; or beneficent circle of events, if good. But the mind, meanwhile, flies into countless supplementary dreams. Transition from type to type in dreams is easy, and the episodic feature of the dream finds but a poor imitation in the moving-picture serial. In emotional dreams the reaction of emotional excitement furnishes the basis for continuity or repetition of the same dream.

Absence of surprise. — The dreamer is not surprised at his power to fly, at his seeing of a dead friend, at his being caught in a most unfortunate situation. Nor does he really appreciate the ludicrous. One can readily dream of surprise or dream of a ludicrous situation as such; but as a rule those situations which in waking life

would excite surprise and the feelings of the ludicrous, the ridiculous, the grotesque, do not excite those feelings in sleep. If they did, the sense of reality of the dream experience would be lost.

Lower plane. — Dream life is ordinarily on a lower moral plane than waking life. There are several reasons for this. Waking life is to some extent what we will it to be. It is a continuous struggle for us to be as good and bright as we are when awake. In the dream this will is in abeyance and the gold and dross of human nature flow mixed and unrestricted in the dream stream. In the narrow sense, it is true that in the dream your character is what you really are; while your waking character is what you wish to seem to be.

Reversion to type. – In the dream there is a reversion to type. The dreamer often lives in his childhood nature or in the earlier types of his race. The reason for this is that the subconscious processes appear through the lower and older structures of the brain. Instincts and habits play an important rôle. Sleep means comparative rest of the latest acquired brain connections through which we show our highest acquisitions of character.

Intellectual feats. — The solving of mathematical problems is the stock example of dream thinking. Volapük, a world language, was invented in this way. The story of Dr. Jekyll and Mr. Hyde was conceived in a dream. The famous Diabola Sonata by Tartini is simply a record of what the dreaming composer heard the devil play. Most people can cite evidences of reasoning, discovery, invention, art production, and similar creative work accomplished in dreams.

The first thing to observe in regard to these dreams is, however, that as a rule they are not so wonderful, so great, so funny, so valuable after due waking reflection upon them as they seemed in the dream or upon the immediate awakening. Do not stake your fortunes on plans conceived in sleep or half slumber.

Emotional sway. — The suffering in dreams is a real suffering, and the pleasure in dreams is a real pleasure. A visit which I make to a dear friend in a dream is to me a real renewal of friendship and has a marked effect in waking life. The pleasures are real and the pains are real. The bodily expression of emotion in nightmare, for example, may be so severe as permanently to impair the nervous system. Likewise, the physical expression of joy, as in beautiful scenery, may be as pronounced as any pleasurable emotion in waking life.

Automatic. — There is no voluntary attention in the dream. The dream attention is passive. You may dream of all sorts of activity of voluntary attention and will, but these are merely dream illusions in which you are represented as willing. All dream action is automatic. Even in the case of sleep walking, the most complicated tasks are performed automatically.

Wish fulfillment. — "The dream is the concealed realization of a suppressed desire." This is the theory of the psychoanalytic school of psychology. It embodies the most profound single fact ever discovered about dreams, and is a most fruitful theory, however extravagant and repulsive it may have been in its first form. This theory has given us a point of view and has stimulated investigation into the nature and meaning of dream life which

has already vitalized psychology materially. However, the method of psychoanalysis is so complicated and so controversial, at the present time, that it cannot profitably be given a place in the elementary textbook, although no thorough study of dreams can now be undertaken without acquaintance with such works as Freud's "The Interpretation of Dreams" and some of its most important sequels.

Veridical Dreams

The problem of veridical dreams (dreams that come true, prophetic, premonitory, and telepathic dreams) has come down to us from ages of superstition and ignorant credulity. The reports on the fulfillment of dreams are notoriously flimsy. The most marvelous dreams are of the round robin type which grow more wonderful for each time that they are told. There is a strong tendency in the human mind to believe the wonderful uncritically; errors of observation, retroactive memory, and narration are notorious. The omission of facts because the narrator does not consider them relevant is a common form of "white lie." Community of ideas is an important explanatory principle. Coincidence goes much further than has been generally supposed as an explanation of these phenomena. In the face of the very massive literature in support of veridical dreams and the very common belief in them at the present time, we are forced, after a critical study of the subject, to the opinion that when *all* the facts are taken into account the marvelous veridical dreams are usually explained — away.

Premonitions that come true. — Among the types of dreams which have been fulfilled when rightly interpreted are the following. There are numerous dreams which give a premonition of a bodily condition. Recently a student reported that during the previous night he had dreamed he was losing his eyesight; that he was in a physician's office suffering in despair over blasted hopes and ambition, feeling that with the loss of sight all happiness was lost. He woke up in the morning to find that a sty had developed in the right eye. A man dreamed that he had been bitten by a mad dog and woke up in the morning to find that an ulcer had been formed on his leg. A patient dreamed that he had been seized with apoplexy and he actually died of that very disease three days later. In such cases dream consciousness was warned of oncoming trouble before the waking consciousness. Such premonitions in allegory or in plain fact may come in an infinite variety of ways regarding matters in the environment as well as in the organism and may be due to heightened sensibility of dream consciousness. In this way persons have been warned in dreams of fire at a great distance, of the suffering of a person in a distant room, and of various other sorts of occurrences just beyond the reach of the normal use of the senses. Then, there is the very interesting class of dreams which cause their own fulfillment. There are cases on record in which a person has dreamed that he should die at a certain time and has died at that very time, probably from the influence of expectation. If one can die simply because he has dreamed that he should die, what cannot one do in the way of fulfillment of dreams under the influence of ex-

pectation? Dreams suggest to us that we shall do certain things and, in obedience to this inner voice, we go and do them. But most dreams which actually come true may properly be classified as coincidences. We dream an endless mass of dreams. We remember only those which are brought up by some association. Now, when something happens, the happening recalls the dream. That particular dream is extricated from the mass of dreams which may never be recalled, and we rightly feel that this dream has been fulfilled. As a matter of fact, it is probably only a coincidence — a result of chance. Many of the most puzzling dreams are explained in this way.

Waking effects. — The greatest significance of the dream lies in its influence on waking life. If we bear in mind that the vast mass of subconscious life which holds full sway in the dream is a continuous stream which underlies our conscious waking life in unrestricted rich interplay, we shall understand how all the experiences of dream life are carried over as organic memories into waking life. Whether the dream is remembered or believed or not, every dream enters into the reactions of waking life.[1]

[1] One day I said at the dinner table, "This is the celery season. It is very good this year. We must have a lot of it for the children." The next day there appeared a luscious bunch of celery on the table and at the first glimpse of it I recalled that the night before speaking of the celery I had dreamed of seeing a hay rack load of the most luscious and appetizing celery hauled into town. This was the first instant that I had been conscious of the dream, but it is easy to see how the menu in this household was changed by a dream which had never been noticed or remembered until after the effect had taken place.

CHAPTER XXIV

INDIVIDUAL PSYCHOLOGY

Individual psychology consists of scientific analyses, tests, ratings, and measurements in the identification of a given individual's psychophysic equipment, both as to original nature or inherited capacity, and nurture or acquired abilities, for the purpose of a scientific understanding, description, and motivation of the individual. In the present chapter, we can only give a few examples of points of view, methods, and interpretations in the use of mental tests, ratings, and measurements.[1] This is the phase of psychology in which we are all interested both as regards knowledge of ourselves and knowledge of others. Indeed, all technical studies in psychology are merely a preliminary to this, for we are working under the slogan, "Know thyself."

Analyzed Rating

Exercise. — *Prepare six blanks like that on the next page. The legends need not be copied. Fill out one of these blanks yourself and*

[1] The word "test" in psychology is quite American and has been adopted in many languages. There is no sharp line of demarcation between test and measurement, but in general the former is used with reference to comparatively simple procedure without laboratory apparatus and for immediate practical purposes; whereas the latter is used with reference to laboratory procedure under well-controlled conditions. From this we should not infer that tests are inferior to measurements; each may be adapted to its place. As a rule, tests are adopted for group examination, whereas measurements can be made on only one individual at a time. But there are important exceptions to this distinction. A rating is merely a record of systematic observation or judgment. Exercise 1 is an example of a mental rating; exercise 2 of a mental test.

ANALYZED RATING OF FITNESS FOR GRADUATE STUDY

	Very Poor 10% (0%–10%)	Poor 20% (10%–30%)	Low Average 20% (30%–50%)	High Average 20% (50%–70%)	Excellent 20% (70%–90%)	Superior 10% (90%–100%)
1. *Reasoning Power:* capacity for solving problems, both deductive and inductive						
2. *Originality:* creative imagination, brilliancy, planful initiative and fertility of rational ideas						
3. *Memory:* extensive, logical, serviceable, and ready command of facts						
4. *Alertness:* quick, incisive, and responsive observation, thought, and feeling						
5. *Accuracy:* precise, keen, regular, and reliable observation, thought, and feeling						
6. *Language:* the use of accurate, terse, and lucid English						
7. *Application:* power of concentration, sustained attention, persistence, and well-regulated effort						
8. *Coöperation:* capacity for intellectual companionship, team work, and leadership						
9. *Moral Attitude:* intellectual honesty, wholesome moral standards, ideals, and influences						
10. *Health:* nervous stability, physique, vitality, and endurance						
11. *Zeal for Investigation:* deep interest in and craving for original and creative work						

ask five members of your class who know you best and in whose judgment you have confidence each to rate you independently and confidentially. Proceed with scientific frankness.[1]

Directions. — Record your judgment on each capacity by placing a check mark (√) at the appropriate point in the dotted line. Compare yourself with college students as a class at your stage of advancement in college. Rate conservatively, bearing in mind that in the long run for a class there should be as many marks below average as above. If in serious doubt, put a question mark above the check. Guard rigorously against giving information to or receiving from others who are rating independently; but otherwise you may discuss the matter freely. At the bottom note (1) specific evidence of achievements which indicate your main *forte*, and (2) evidences indicative of your main *fault*.

Purpose. — The object of this analyzed rating is to secure a fairly clear picture of your endowment for advanced and original work as a student. The record should give a profile showing the relative prominence of each of the features listed. A person may be very high in one capacity and low in another. No one is uniformly high or low in all. These capacities are not of equal value. One feature may be essential for one field of pursuit; another feature for another. The records should never be averaged.

This inventory should operate to discover your fitness for further education regardless of present plans, and

[1] Printed or mimeographed sheets may be supplied. This blank is now used extensively in the selecting of candidates for stipends and honors.

To save time the ratings may be recorded in terms of per cent and all transferred to one chart. The dots represent 2% steps.

should serve as a starting point in self-analysis and a guide in consultation with your superiors. File the six profiles with your diary or private papers, for,

> "Oh, wad some power the Giftie gie us
> To see oursel's as others see us."

Among the important features of this rating is the fact that you were forced to think systematically about yourself and to register your judgment with discrimination. The analysis feature, requiring you to judge one thing at a time, brought out the fact that you have high points and low points, and that these differences are of vital significance to you in the full planning of your studies and the selection of a career. There are serious sources of error in such rating, but a study of the differences in the six ratings throws much light upon the character of particular fitnesses or faults from different angles of observation. Often disagreements throw valuable light on the situation. The seriousness and thoroughness with which you follow up a lead of this kind is the best mark of fitness. Individual psychology is only a matter of curiosity unless it is used as a basis for guidance in action.

Personnel rating in the army. — The most notable example of the use of an analyzed rating system in personnel work is that which was adopted as a basis for selection and promotion in our army during the late war. When confronted with an enormous army in which appointments, assignments, and promotions had to be made, such principles as seniority, personal acquaintance, and records of achievement were found inadequate. The government, therefore, turned to methods of " business

efficiency," a concept which had just come into vogue from applied psychology. The Adjutant General issued an order directing that, with the exception of a few at the top, men of all ranks should be rated at stated intervals on five points: physical qualities, intelligence, leadership, personal qualities, general value to the Service. These ratings, assembled at headquarters, became cumulative, and were kept daily so ranked in a card catalogue that on a few minutes' call the assignment or promotion of an individual, a score, a hundred, or a thousand men could be made on merit at headquarters; because these cumulative ratings, together with the mental test record, the full questionnaire information collected on enlistment, and the cumulative army record taken together furnished an up-to-date inventory in terms of which the personnel cards were daily sorted in anticipation of call for action. The rating card was the medium through which each officer could register effectively his judgment of merit from time to time. Many did not know that there was any "psychology" in this system of promotion; indeed, this furnished a good illustration of how science at its best becomes common sense. This is the goal of individual psychology — that its methods and aims shall become so natural and reasonable as to be taken for common sense or good business. The method had great shortcomings in the emergency use during the War, but in the modifications and adaptations being made since demobilization, the method of analyzed rating occupies an important place in our army organization. There is a gradual transition from ratings to tests and measurements: the better the rating the more it deals with observation under control.

Tests

Subject matter test. — The school examination is the original form of mental test. From this have developed highly specialized methods of testing ability or achievement in school subjects, such as reading, writing, arithmetic, spelling, geography, stenography, and composition in terms of which we can measure progress and fitness of the individual and organize content of courses. On this plan we now have standardized scales, such as handwriting scales, reading scales, composition scales; and, within each of these, there are scales for specific features. Thus, in the arithmetic scales we have separate norms for addition, subtraction, multiplication, and division. To pass the Courtis test in Addition in a given grade means the same thing from school to school and from year to year, and is capable of universal and permanent standardization. That scale in itself has done more than anything else for the founding of principles of teaching addition and school administration in arithmetic. For grading of individuals, it gives us a standard of measure quite analogous to the pound or the inch. Before its adoption, evaluation of arithmetic ability was on the basis of primitive barter.

Tests of occupational fitness. — The principle of measuring fitness for a particular task has been extended into many sorts of practical situations, so that we now have tests for the purpose of occupational selection fast taking the place of the crude method of snap judgment and the economic waste of "trying out" personnel indiscriminately, *e.g.*, in the selection of clerical help, machine operatives, salesmen, and even college students.

The introduction of this method of selection and sorting at the employment stage has forced the schools to consider fitness for a given occupation before accepting students for a course of specific occupational training. Vocational *selection* at the earning stage has thus led to vocational *guidance* at the educational stage. Both are yet in a very crude state, although great ingenuity has been displayed in recent years in developing the technique of individual psychology for these purposes.

Psychology, thus applied to the individual, has led to job analysis — a systematic, psychological study of the job or occupation for the purpose of determining what mental and manual factors are involved. Each occupation requires a certain type of fitness and this must be taken into account for the purpose of fitting the individual to the job. Of two persons equally valuable to society, one may be highly fitted for a given occupation, and another utterly unfit, although possessing high qualifications in other directions. Failure to take these individual differences into account in human occupations has been the source of enormous waste, suffering, and sacrifice. One job, for example, requires good eyesight, good memory, and quick discrimination; another requires quick reaction time, emotional stability, and good judgment; another artistic temperament, creative imagination, and initiative; another good visual imagery, memory for form, and a keen sense of color. These four fragments of job specifications call for radically different personnel equipment.

It is the theory of job analysis that each job should be filled by a person who has natural capacity for that kind of job; because only then will he be at his best,

happy, at ease, and able to render the best service. We have on the one hand, then, analysis of the job, and on the other, analysis of the individual. It is the duty of society to use its best efforts to find the right person for the right job, from the humblest occupation to the highest, involving special capacities. That is the third link in the chain; it applies to both selection and guidance.

One of the finest applications of this principle in modern times is in the treatment of the feeble-minded, for it has been found that if you determine the remnant capacities of these unfortunates and place them in a busy life with reference to capacity for achievement, children who have been a curse to themselves and their homes may, in a well-regulated institution, be made happy, useful, and good. And what is true at these lowest levels of human achievement has correspondingly greater possibilities when applied to the intelligent direction of human energies of the normal and especially the highly gifted.

One of the most striking observations in personnel direction is that many important jobs do not require the exercise of certain otherwise valued mental traits, such as memory, imagination, and strength of intelligence. On the other hand, there are a great many occupations in life which require a rather broad group of powers. Such are the professions of law, medicine, engineering, and teaching. It would be difficult to say that one individual is fit for one and not for the other. On the other hand, there are marked requirements of fitness for what may be known as the professional group of intellectual activities.

Tests of general intelligence. — The Binet-Simon tests are the original and best known series of tests of what is

called general intelligence, mental age, mental alertness, mentality tests. They depend on the principle that it is possible so to grade a series of tasks as to constitute a norm for the maximum achievement at each successive age level. If the child succeeds in the performance of the task normal for his age, but fails in the tasks for the next year above, he is said to be at age, or normal. Deviation from this is marked in terms of year or half year above or below normal, as the case may be, and the rating is designated as his mental age. This principle, adapted to the rating of adults in the army, led to the discovery that the average mental age of the enlisting American soldier in the late war was 13.15 years. The method of arriving at this figure is subject to criticism, but the finding is probably not far from the truth and furnishes a rather striking illustration of how tests reveal very surprising conditions which, when closely examined, seem natural and reasonable.

Since a deviation of one year is more significant in the earlier than in the later years, the designation of intelligence quotient (I.Q.) has been adopted in the place of mental age. The I.Q. is the ratio of mental age to chronological age: it is found by dividing the child's mental age by his chronological age and expressing it in terms of per cent. An I.Q. of 100 would therefore be normal. Terman gives the following interpretation in classification:

I.Q.	
Above 140	"Near" genius or genius
120–140	Very superior intelligence
110–120	Superior intelligence

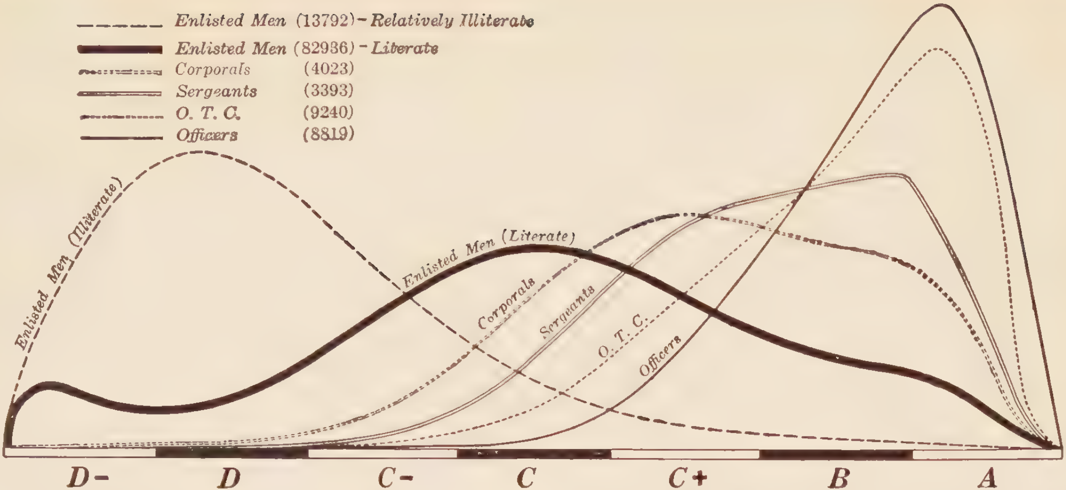


FIG. 22. — The distribution of intelligence ratings in typical army groups, showing the value of the tests in the identification of officer material. The illiterate group given Beta (a picture test); other groups Alpha.

The psychological ratings have proved valuable not so much because they make a better classification than would come about in the course of time through natural selection but chiefly because they greatly abbreviate this process by indicating **immediately** the groups in which suitable officer material will be found, and at the same time those men whose mental inferiority warrants their elimination from regular units in order to prevent the retardation of training. Speed counts in a war that costs fifty million dollars per day.

90–110	Normal, or average, intelligence
80–90	Dullness, rarely classifiable as feeble-mindedness
70–80	Border-line deficiency, sometimes classifiable as dullness, often as feeble-mindedness
Below 70	Definite feeble-mindedness

Although tests of this order are yet crude and have been much abused, they have proved to be an invaluable tool in human engineering. They are coming into official recognition in our institutions and schools for the segregation of the defective, the delinquent, the criminal, and those otherwise unfit; they are used extensively for a general and superficial index in all sorts of activities from the kindergarten up to the specialized professions.

The army mental tests. — When we entered the War in 1917, we were confronted with the gigantic problem of selecting, sorting, and assigning millions of men by the quickest procedure possible. The American Psychological Association was called upon to answer the question, "Can psychology help in this project of human engineering?" The result was the organization of the now famous system of army mental tests. The Alpha test marked an epoch in history. It was organized on the general scheme of the intelligence test plan. The specific purposes were to aid: —

"(1) In the discovery of men whose superior intelligence suggests their consideration for advancement; (2) in the prompt selection and assignment to development battalions of men who are so inferior mentally that they are suited only for selected assignments; (3) in forming organizations of uniform mental strength where such uniformity is desired; (4) in forming organizations of superior mental strength where such superiority is demanded by the nature of the work to be performed;

FIG. 23.—Success in civil occupations compared with army test records. The figure shows in a general way the correlation between intelligence as measured by the army tests and intelligence as indicated by position in civil life. From p. 829, *Memoir XV*. (After Brigham).

(5) in selecting suitable men for various army duties or for special training in colleges or technical schools; (6) in the early formation of training groups within regiment or battery in order that each man may receive instruction and drill according to his ability to profit thereby; (7) in the early recognition of the mentally slow as contrasted with the stubborn or disobedient; (8) in the discovery of men whose low grade intelligence renders them either a burden or a menace to the service."

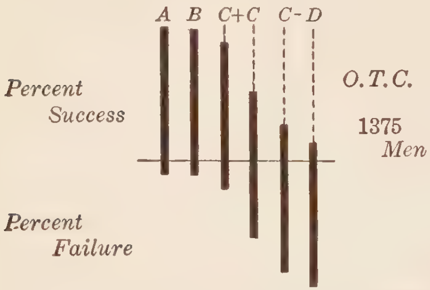


FIG. 24. — Success and failure in Officers' Training Schools

Note the rapid increase in elimination in grades below B. Of those above C+, 8.65 per cent were eliminated; of those below C+, 58.27 per cent.

The intelligence record was converted into grades on a scale of 7 from D to A as follows:

Intelligence Rating	Interpretation	Distribution %
A	Very Superior	3.5
B	Superior	7.5
C +	High Average	13.5
C	Average	21.5
C –	Low Average	22.0
D	Inferior	22.0
D –	Very Inferior	10.0

Figs. 22 and 23, from the official report of the army mental tests, indicate in two different ways the distribution of intelligence in the army.

Since it was found that this kind of intelligence is

differently distributed for different ranks in the army, it was found possible to predict fitness for a given rank at the time of enlistment for admission to the training school. Figs. 24 and 25, from the same source, are striking illustrations of the success of this prediction, which is a measure of the value of the tests. We have already seen how the intelligence record was used with the personnel rating for assignments and promotions.

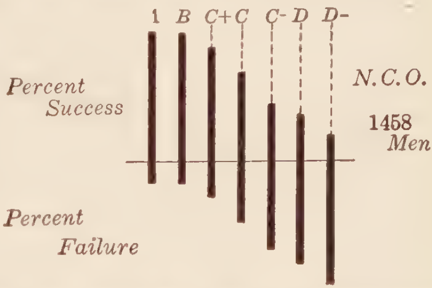


FIG. 25. — Success and failure in Non-commissioned Officers' Training Schools

Note the rapid increase in eliminated in the grades below C. Of those above C, 18.49 per cent were eliminated; of those below C, 62.41 per cent.

Tests of specific capacity. — With the development of procedure in mental testing, there is a tendency to develop intensive tests for specific factors. Thus we now have tests of various kinds for sensory discrimination, visual imagination, reasoning, emotional reaction, attention, memory, etc. We may take as an example of this class a test of the ability to read, known as "Comprehension Test B1," which is given on page 398.

EXERCISE. — *Take the test marked "Comprehension Test" under the rigid conditions of the directions. The correct answers are given later in this chapter. Do not, under any circumstances, look at them before you have completed the test. (That is a test of intellectual honesty!)*

COMPREHENSION TEST (B1 Iowa Series 9-25-21)

Directions: Answer the twenty questions on the opposite page, only by quoting words or phrases from the text. You are allowed 25 minutes' time. Review answers. Remember to answer only by direct quotation from the text.

We thank you for the order recently given to Mr. Oaks, and shall immediately forward the goods.

Nowadays it is the practice of nearly all merchants to submit at intervals of not exceeding a year, statements of their financial condition. Sometimes these reports are made through the mercantile agencies and sometimes direct to the wholesalers. So far as we can find you do not appear to have given this information to any one and therefore we lack the data upon which to form a positive opinion as to your financial condition. Mercantile authorities speak well of you in a general way and we believe you are entirely responsible. If it had been your custom to pay your invoices promptly or to discount them, favorable information of that character would be a satisfactory basis for such credit as you may require of us; but when you so frequently permit our invoices to run beyond their maturity before settlement we feel that as a reasonable business proposition we are fairly entitled to a closer knowledge of the situation. Any report which you may submit to us will, if you so instruct, be held strictly confidential and you will find the better acquaintance between us thus brought about will be beneficial to yourselves as well as to us. It hardly requires argument to support the proposition that when a merchant frequently finds it inconvenient to pay at maturity, a frank disclosure of his financial condition, if his affairs are on a substantial basis, will result to his advantage.

If your merchandise has not recently been inventoried, your conservative estimate of its value will answer. Precise and complete figures of the indebtedness are desired, but your books will enable you very quickly to give the information requested in our letters of August 10 and August 20. We again ask if you will not kindly let us have at once the brief report suggested by the printed blank enclosed, and assure you your prompt and favorable consideration of this request will be much appreciated.

Our monthly statement of your valued account showing overdue items to the amount of $684 is enclosed. Kindly let us know your pleasure concerning them.

Please accept our best wishes for your continued prosperity.

(Letter adapted by Gardner)

QUESTIONS ON THE COMPREHENSION TEST

1. How much does the merchant owe the writer?
2. When, before, has the writer requested the information in question?
3. What current practice among business men is mentioned?
4. Under what conditions will the report, if submitted, be kept strictly confidential?
5. How soon does the writer want the report?
6. How often are such reports usually made?
7. What promise of secrecy is made concerning the report expected?
8. What material is provided to facilitate the report?
9. What in general do the reporting agencies say of the merchant addressed?
10. Where can the merchant obtain the facts requested in the previous letters?
11. Through what two channels are the financial conditions usually made known?
12. How certain is the writer that no report of the merchant's financial condition has been made?
13. What two enclosures are made with the letter?
14. Will the present order be filled under the existing conditions?
15. In what event does the writer state that an approximation of the value of the merchant's stock will be accepted?
16. Is the writer disposed to regard the merchant responsible?
17. What does the writer state will be brought about by any report the merchant may see fit to make?
18. When will it be advantageous for a merchant whose business is stable to make known his financial condition?
19. Under what conditions is the writer willing to accept the merchant's estimate of the value of his stock?
20. What two clauses repeat the idea "a closer knowledge of the situation"? [1]

This test has been standardized for various ages and degrees of educational advancement. Fig. 26 gives the norm for high school students at college entrance in the Middle West. Of this group, from 10–15

[1] This type of test has recently been changed so that the answering and the scoring are both made by numbers.

per cent proved incapable of carrying freshman work in college.

To obtain your rank after you have faithfully performed the test as directed, (1) check the answers that are right by giving five credits for each correct answer; (2) add these points to obtain the per cent right; (3) locate this "per cent right" at the bottom of Fig. 26,

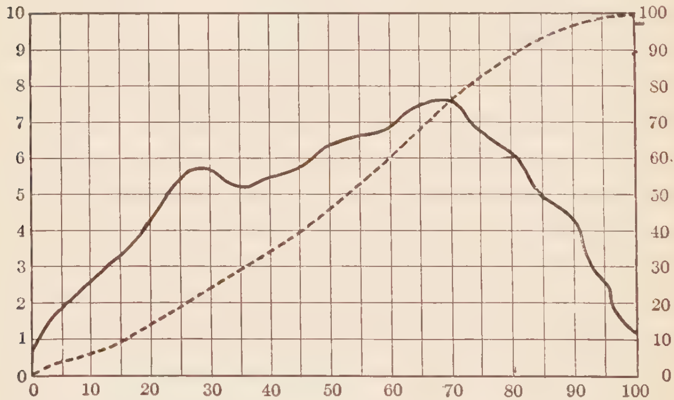


FIG. 26. — Distribution and norms for Comprehension Test B1
Solid line, distribution of cases in each score indicated at the bottom; per cent of cases in each score at left; dotted line, norm for determining the percentile rank of any individual record, percentile rank being indicated at the right.

and follow the vertical line from that point to the norm (dotted line) and thence horizontally to the right margin where the scale of percentile rank will indicate the rank you have earned on this standard. Then (4) run a vertical line from the "per cent right" to the distribution curve (solid line), and you can see at a glance the relative frequency of cases at your level of capacity in terms of

norms established for high school graduates at college entrance.

You have thus acquired a bit of specific and quantitative knowledge about yourself as an individual in such a way that you can compare yourself with others. Interpret the significance of this with reference to your success in studying a lesson, your achievement in noting facts under the microscope, your ability to see the argument in a debate, and in general, to your ability to comprehend and report any situation and act on that comprehension.[1]

The Measurement of Musical Talent

As an example of an individual psychology for a specific field of human achievement, we may take the psychology of musical talent regarded as a scientific foundation for vocational and avocational activities

[1] *Key to Comprehension Test BI.*

1. "$684"
2. "August 10, 20" ("August 10, August 20")
3. "to submit. . . . . . . .statements of financial condition"
4. "if you instruct"
5. "at once"
6. "at intervals of not exceeding a year" ("not exceeding a year")
7. "be held strictly confidential" ("strictly confidential")
8. "printed blank"
9. "speak well of you" ("speak well")
10. "your books" ("books")
11. "mercantile agencies, wholesalers"
12. "so far as we can find" or "you do not appear to have given this information" or "we lack the data"
13. "blank, statement"
14. "shall forward the goods"
15. "if merchandise has not recently been inventoried"
16. "we believe you are entirely responsible"
17. "better acquaintance" or "will be beneficial to yourselves as well as to us" or "will result to his advantage"
18. "when a merchant finds it inconvenient to pay at maturity"
19. "if merchandise has not recently been inventoried"
20. "a frank disclosure of his financial condition," "precise and complete figures of the indebtedness" or "positive opinion as to your financial condition"

in music. The procedure here briefly noted is adaptable to many other fields.

In addition to a general mental development, musical talent consists of excellence in certain capacities essential for the appreciation, rendition, or creation of music. It is not one gift, but many coöperating. The following list of factors in musical talent is representative:

- I. Musical sensitivity
  - A. Simple forms of impression
    1. Sense of pitch
    2. Sense of intensity
    3. Sense of time
    4. Sense of extensity
  - B. Complex forms of appreciation
    1. Sense of rhythm
    2. Sense of timbre
    3. Sense of consonance
    4. Sense of volume
- II. Musical action

  Natural capacity for skill in accurate and musically expressive production of tones (vocal, instrumental, or both) in:
    1. Control of pitch
    2. Control of intensity
    3. Control of time
    4. Control of rhythm
    5. Control of timbre
    6. Control of volume
- III. Musical memory and imagination
    1. Auditory imagery
    2. Motor imagery
    3. Creative imagination
    4. Memory span
    5. Learning power
- IV. Musical intellect
    1. Musical free association
    2. Musical power of reflection
    3. General intelligence
- V. Musical feeling
    1. Musical taste
    2. Emotional reaction to music
    3. Emotional self-expression in music

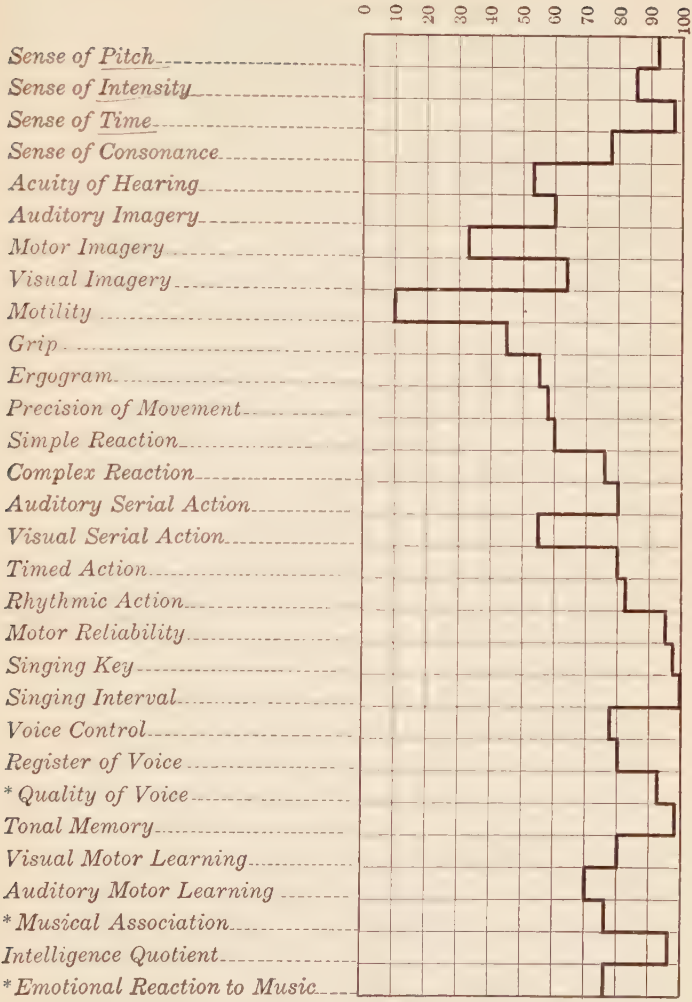


FIG. 27. — Musical talent chart of Theodora X

The items marked with an asterisk in the chart represent mere estimates in the absence of norms.

Most of these capacities are measurable either as a whole, as in the first four items, or in isolated specific aspects of a general capacity as in the last group.

Fig. 27 is a typical musical talent chart. This is the case of a highly gifted ten-year-old girl, based on laboratory measurements. To one who is familiar with the significance of the measurements, this picture furnishes a graphic profile. It illustrates, is the foundation for, and vitalizes the legend which constitutes the report of the examination which reads as follows:

"Theodora has a decidedly musical mind. In the three basic capacities for musical hearing — the sense of pitch, the sense of intensity, and the sense of time — she is superior and well balanced. Her sense of consonance is of a high order. Her acuity of hearing is only average, but this condition is not of the type which will affect music seriously in view of her superior sense of intensity. Her imagery is all of the moderate type. Her auditory imagery can be developed as an excellent support to her superior sensory powers and the motor and visual imagery are prominent enough for an emotional background in music. Her lowest record is on motility, which is characteristic of the fact that she has a deliberate type of mind and is steady in her movements. Her physique is average, as indicated by her grip and ergogram. Her precision of movement and her simple response to a simple signal are slightly above average; while her simple response to a complex signal is decidedly better. Her capacity for serial association of sound and action is good; whereas her association for visual impressions and action is barely above average. Her timed action and her rhythmic action are both good. Her general motor reliability is superior. She sings in

key with remarkable ability and reproduces the interval with superior precision, although her voice control is only moderately good for nuances of pitch. She has a good voice register and an excellent voice quality. Her tonal memory is decidedly superior. She gives superior promise for speed and reliability in the acquisition of skill in music. Her associations are highly versatile and remarkably well balanced, but not peculiarly musical. Her mental age is fully two years in advance of the normal. Emotionally, she is cool and undemonstrative, but capable of deep feeling for music."

Delineations of this type are now made of every pupil upon entrance to certain music schools. It serves as an inventory or a budget of the available talents which makes parents and teachers deliberate and plan before deciding upon the kind and extent of training to be sought.

The examination may be made as extensive as facilities permit and the importance of the case may warrant. For those intending to enter upon a professional career it may be made very searching. The same principles may also be employed in diagnosing the difficulty when failure in musical education or career has been encountered. In the interest of first search for talent, the most fundamental measures are now being made in the sixth and eighth grades in the public schools by means of the phonograph records.[1]

[1] When the searchlight of measurement is thrown on the situation, the challenge that comes to the music teacher with records of talent raises such questions as these: (1) Do I fully realize the magnitude and significance of individual differences in my pupils? (2) Do I believe in giving each individual pupil in music an opportunity commensurate with his actual capacity and aptitude? (3) Do I actually in practice give my pupils an opportunity to grow, each according to his talent? (4) Do I keep the pupil always at his natural level of achievement? (5) Do I justly praise or blame the pupil? (6) Do I rightly identify the retarded child? (The retarded child is the bright child who is held in leash to keep step with the class.) (7) Do I motivate my work for each

A study of school children by means of these measures has revealed countless cases of talent hitherto unrecognized and undeveloped; has helped in the identification of known talent by objective analysis; has furnished explanation of the exhibition of unusual talent; has certified the absence of talent; has illustrated in a striking manner the magnitude of individual differences; has enabled the teacher to verify theories of talent; has shown that musical talent is equally distributed among high and low; has put the problem of the bright and the dull in a new light; has proved that it is possible to test the trained and the untrained alike; has shown that pupils in singing are not ordinarily grouped on the basis of talent for singing; has proved that likes and dislikes as stated by children and even by adults are a very doubtful indication of talent; has demonstrated that musical talent may be measured as early as in the fifth grade, or the tenth year; has opened a new approach to the study of musical inheritance; and has awakened the teacher to an interest in the study of the pupil as an individual. It has set an example of a scientific approach to the problem of the conservation of human energies, especially the more precious talents.

The psychogram. — The talent profile, as in Fig. 27, is an example of a psychogram. The data may be obtained by varied methods and may be of different value. The main point in the profile is that it represents rela-

individual? (8) Do I help my pupil to find himself, or am I simply satisfied to allow him to drop into a class mold? (9) Do I take into account the individual as a whole? — his bodily development, his social development, his intellectual development, his moral development, his esthetic development, and his religious development in music?

tively specific factors in quantitative terms on a common scale. It has been a dream of enthusiasts to develop psychograms which should picture the individual as a whole, but we here encounter the principle that with increase in extensity we lose in intensity. While the general profile is valuable as a preliminary, individual psychology demands that it shall be intensive so as to show sufficient detail. To the extent that this is done, it becomes necessary to select some specific aspect, such as *a* talent. Control of the situation always reveals the necessity of analyzing the data into fine detail.[1]

Psychograms have hitherto dealt mainly with the intellectual and motor capacities, but the affective phase of man is of fully as great significance for the evaluation of fitness. However, we still lack satisfactory approach to the testing, rating, or measuring of the affective and moral traits.

Individual psychology has often met opposition because it "bares the individual." Some of us do not object to having our height and weight known, but many draw the line when it comes to any objective rating of intelligence or imagination. It is regarded somewhat in the same way as testifying against one's self. This will, however, change to a great extent.

Labor organizations have objected to the application of individual psychology on the ground that it would discourage uniformity of treatment. But the time has passed when one man can be regarded as good as another.

[1] The items in Fig. 27 do not correspond in detail to the items in the analysis of musical talent above because many types of measurements may be made under each item in the analysis and the chart shows what actual measurements were made.

It has also been charged that individual psychology has as its main goal the principle of efficiency. In its inceptive stage that seems to be true because that is what people first demand. But individual psychology is not so limited, for it reveals the nature, capacity, and needs of the individual as a bodily, intellectual, moral, social, esthetic, and religious being, and voices the demands of the individual for self-realization in these capacities and rights. The economic principle will foster individual psychology just as it has fostered temperance and peace. But the economic issue is not the great issue involved in either temperance or peace, though it may be the immediate and efficient pressing issue. So the principle of efficiency is, perhaps, most conspicuous in individual psychology, whereas the principle of self-realization in the fullest sense is its real objective.

APPENDIX

Some Illustrations of the Structure of the Nervous System

The figures introduced in this section are the conventional figures now in vogue in elementary textbooks, and are such common property that, for the present purpose, there seems to be no object in indicating the sources from which they were originally derived.

The student should have access to a good elementary manual on the nervous system, such as Lickley, *The Nervous System*, Herrick, *Introduction to Neurology*, or a good textbook in physiology. The presentation of the subject in this Appendix is intended merely as an aid in review work.

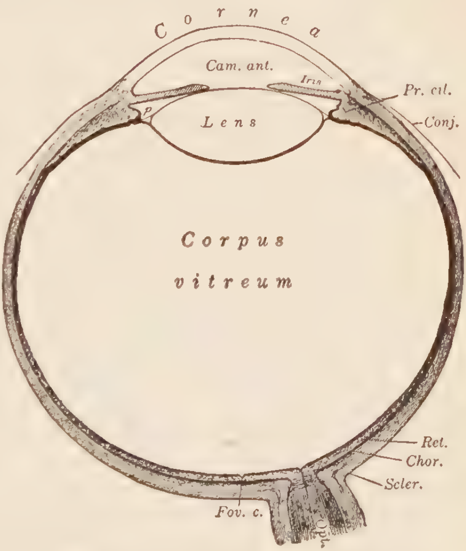


Fig. 28. — Cross-section of the eye

The eye. — The eye (Fig. 28) is a living camera. The darkened chamber consists of three coats: (1) the *sclerotic*, a tough sup-

porting and protecting membrane, taking the form of the translucent *cornea* in front of the lens (where it has an exterior lining, the *conjunctiva*, which is exceedingly sensitive to pain and pressure); (2) the *choroid*, which carries nerves and blood vessels and serves to darken the chamber, being modified in front into the circular *iris diaphragm* which adjusts the area of illumination (pupil); and (3) the *retina*, a sensitive film, which consists essentially of a spreading network constituting the termination of the optical nerve.

FIG. 29. — Left eyeball showing the large muscles

The focusing system consists of four refracting media: the *cornea*, the *aqueous humor* of the anterior camera, the *crystalline lens*, and the *vitreous humor*. The most important of these is the lens, which is capable of focusing for different distances through the action of the ciliary muscle (ciliary process) upon the capsule which holds the lens.

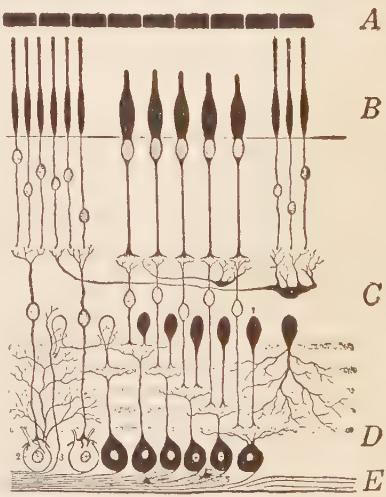


FIG. 30. — Cross-section of the retina

The eyeball is supplied with six large external muscles

(Fig. 29); namely, the four direct muscles — the superior, the inferior, the external and the internal *rectus*, which turn the ball up, down, outward, and inward respectively; and two *oblique* muscles, acting at right angles to the direct muscles, for the purpose of rotating the ball upon its axis.

A cross-section of the retina (Fig. 30) may be divided into five parts. Counting from the top of the figure, from the choroid toward the center of the eyeball, there is, *A*, a layer of pigmented cells, the *visual purple; B*, a layer of *rods and cones*, the end-organs of vision; *C*, the *bipolar cells*, which serve to amplify and transmit the impulse from the rods and cones to *D*, the *nerve cells* from which *E*, the *axons* unite to form a branch of the *optic nerve* to the brain.

The ear. — The ear consists of three parts: the *external*, the *middle*, and the *inner*.

The external ear (Fig. 31) consists of the *auricle* and the *external auditory cavity A*, ending in the *tympanic membrane B*.

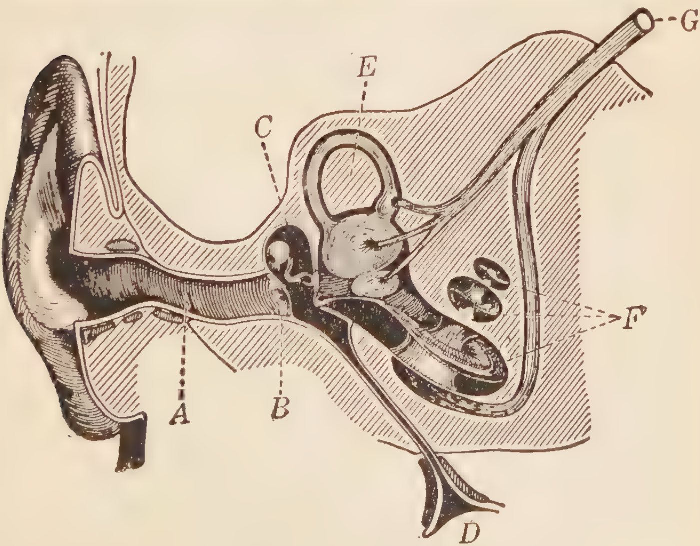


FIG. 31. — Cross-section of the human ear

The middle ear consists of the cavity *C* containing the three bones, the *hammer*, the *anvil*, and the *stirrup*, which together act as a transmitting lever from the tympanic membrane to the *oval window* into which the stirrup fits.

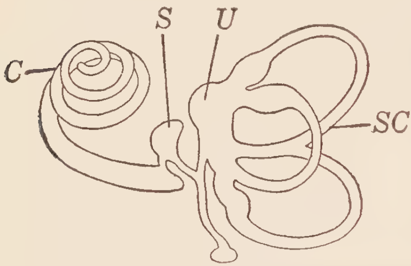


FIG. 32. — Model of the bony labyrinth of the ear

The inner ear consists of two parts: the *semicircular canals* (*E*, Fig. 31; *SC*, Fig. 32) with the *utricle* and *saccule* (*S*, *U*) which are the organs of equilibrium; and the *cochlea* (*F*, Fig. 31; *C*, Fig. 32), which is the organ of hearing. Each of these is supplied with a branch of the *auditory nerve G*.

The cochlea is composed of a *bony labyrinth* with two and one-half windings in the snail-shell structure. The canal is divided by the bony shelf (2 in Fig. 33, *limbus laminae spiralis*, Fig. 34), which is continued as the *basilar membrane* (Fig. 34) into the *tympanic* canal (3, Fig. 33) and *vestibular* canal (1, Fig. 33. Cf. *scala tympani* and *scala vestibuli* in Fig. 34). Both are filled with a liquid called *perilymph* which is set into vibration by the stirrup and causes a compensatory movement in the membrane of the *round window* at the other end of the canal, close by the oval window, as is shown in the

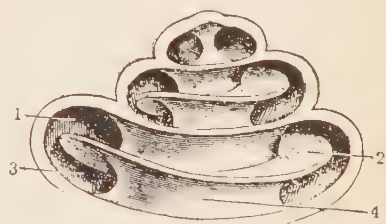


FIG. 33. — Cross-section of the bony structure of the cochlea

figure. Inside of the vestibular canal is a *membranous labyrinth, ductus cochlearis,* of which the basilar membrane forms one side. It contains a liquid called *endolymph*

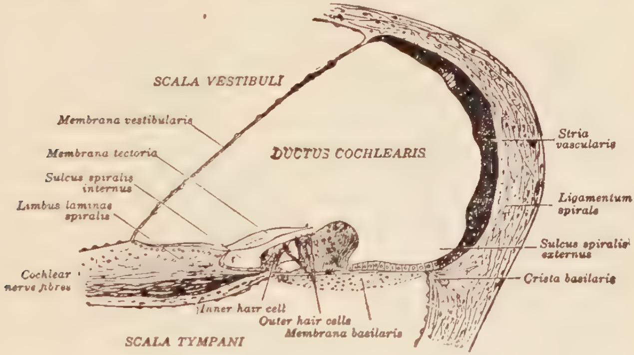


FIG. 34. — Organ of Corti

which is set in motion by the vibrations of the perilymph. In Fig. 34 the parts of the organ of Corti are named.

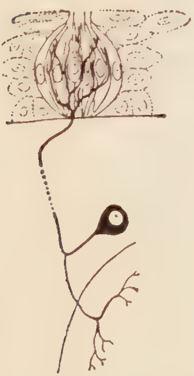


FIG. 35. — The organs of taste

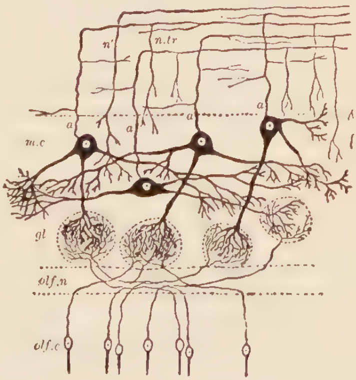


FIG. 36. — The organs of smell

Briefly, the mechanism of hearing is this: sound waves from the air are collected by the outer ear and transmitted,

in order, through (*a*) the tympanic membrane, (*b*) the chain of bones, (*c*) the perilymph, (*d*) the endolymph, (*e*) the basilar membrane and possibly the tectorial membrane and

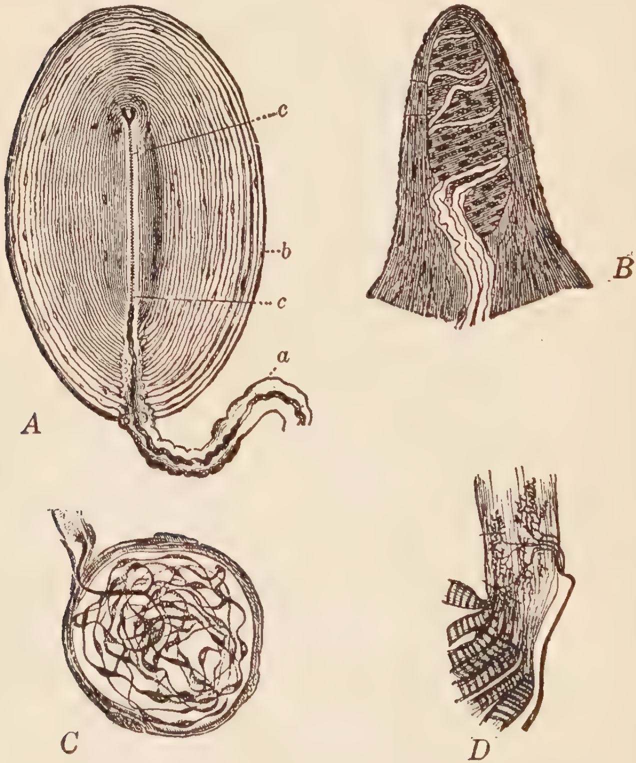


FIG. 37. — End-organs in the skin, muscles, and tendons

the hairs on the hair cells, and (*f*) the rods of Corti, to (*g*) the hair cells which are thereby mechanically stimulated so as to cause chemical action in the nuclei, which is the beginning of the nerve impulse. That is then transmitted over

nerve fibers which combine to form the *cochlear branch* of the *auditory nerve* running to the brain.

Organs of the lower senses. — In Fig. 35 a *taste flask* is shown with its *pore* opening to the surface, the *hairs* from the taste cells, the *bipolar cell* with its network of the afferent branch around the taste cells and its efferent terminal in the brain.

The end-organs of smell (Fig. 36) lie in the *olfactory bulb*, which is genetically an extension of a lobe from the brain. The *olfactory cells* (at the bottom of the figure) lie in the lining of the mucous membrane and send their branches to the *brain cells* which lie in the bulb; the axons from these cells form the *olfactory tract*, which is the nerve of smell.

In Fig. 37, *A* is the *Pacinian corpuscle* found in the deeper

FIG. 38. — Some types of neurons

layers of the skin and in certain muscles; *B* is *Meissner's corpuscle;* and *C* is *Krause's corpuscle.* These three may be spoken of as the spring, the spindle, and the bulb respectively, and are generally regarded as the end-organs of pressure. Some of them are also probably the end-organs of strain. *D* shows the branching of the kinæsthetic nerve fibril in a tendon.

The central nervous system. — In Fig. 38, the general plan of the *neurone* is best shown in *B*, which is a motor

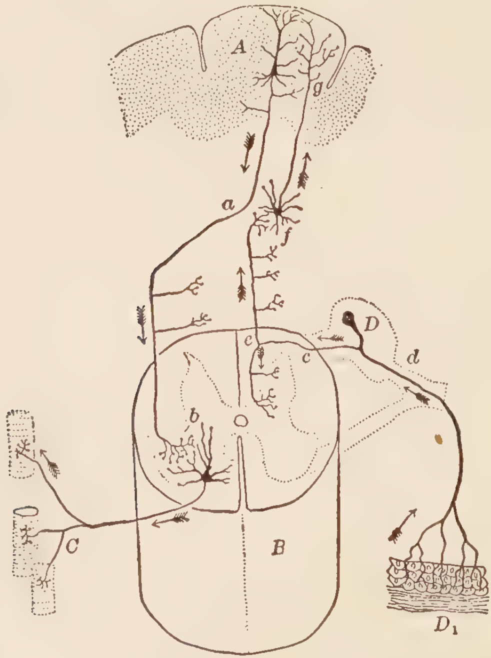


FIG. 39. — General scheme of a neural arc

neurone, showing the tree-like *dendrites*, the *nucleus* of the *cell body* and the *axon*. *D* is a pyramidal cell typical of the

principal layer in the cortex of the brain. *A* is a neurone from the cerebellum, remarkable for its rich system of dendrites. *C* is a connecting neurone. In all these figures, *a* indicates the axon.

Fig. 39 is a very crude schematic representation of the organization of the *neural arc* illustrating the course that the nerve impulse will take, *e.g.*, when a finger is withdrawn from the prick of a pin. *A* denotes the brain and *B* the spinal cord. D_1 is a sense organ in the skin, *D* a bipolar cell, *f* a brain cell in one of the basal ganglia, *a* axon from the pyramidal cell in the cortex of the brain, and *C* a motor neurone in the spinal cord with fine branching of its axon in muscle fibrils.

The *spinal cord* is a grand trunk cable between the brain and the sensory and motor end-organs. It is a double organ containing the cables running into the brain in each half of the back side and the cables running out from the brain on each side of the front. The smaller nerve trunks are connected from the respective levels of the body throughout the length of the cord. The sensory and the motor nerves join in a single cable from each level.

In Fig. 40, a segment of the spinal cord is shown (*A*) from

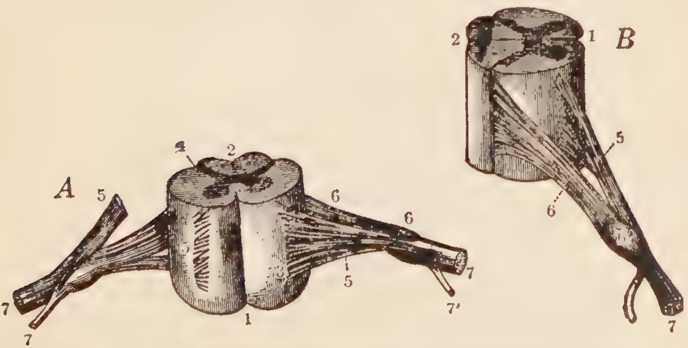


FIG. 40.—Cross-sections of the spinal cord with nerve roots

the front and (*B*) from the right side. 1 is a *median fissure*, 2 the corresponding fissure at the back, 3 the *roots* of the motor branch, 5 the *motor branch* of the nerve trunk, 6 the *sensory branch* of the nerve trunk, 7 a *spinal nerve*, and 7′

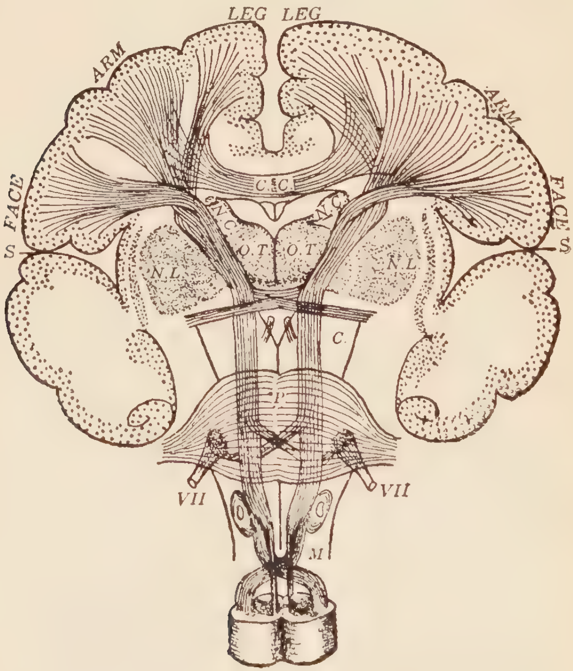


FIG. 41. — Schematic lateral section of the brain

fibers to and from the *autonomic system.* The light shaded area represents the white tissue, or cable of axons running up through the back and down through the front symmetrically in the two halves. The dark shaded area is cellular and contains the *spinal centers* for the respective levels.

The general scheme of the connection between the brain and the spinal cord is shown in Fig. 41. At the surface of the

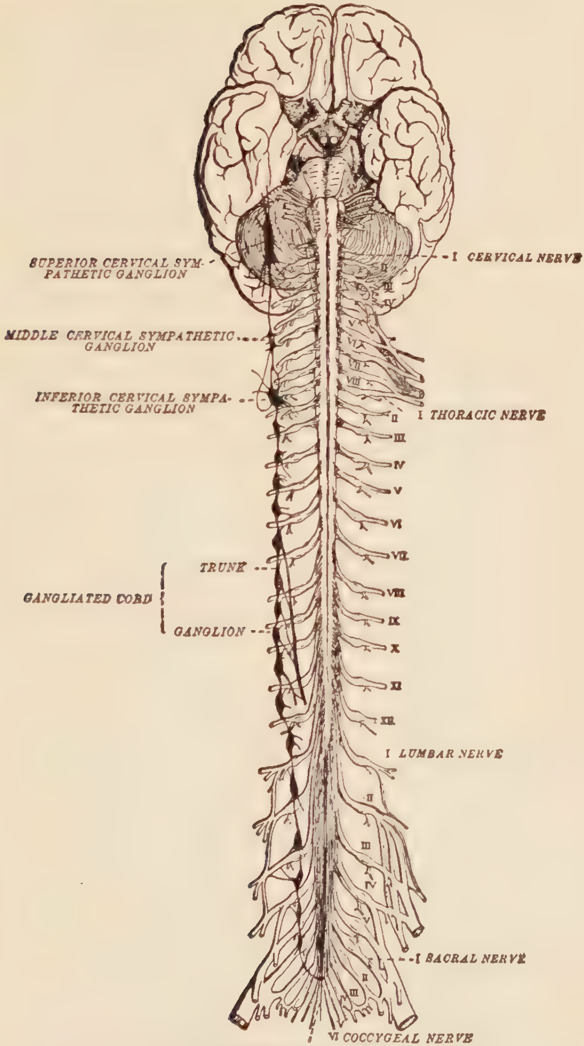


FIG. 42. — The human central nervous system and autonomic system

brain, the respective regions that govern movements of face, arm, and leg respectively, and their connection downward into the cord are indicated. *S* is one of the large fissures of the brain, the *fissure of Sylvius; P* is the *pons*, the vertical fibers at *C* are the *projection fibers*, *CC* are the *commissural fibers*, *OT* is the *optical thalmus*, *NL* the *internal capsule*, and VII the facial, or seventh pair of *cranial nerves*. Note that the projection fibers from the two sides of the brain cross in the *medulla, M*.

Fig. 42 shows the central nervous system composed of the *cord* and the *brain*, together with the chain of ganglia in the *autonomic nervous system*, viewing the cord from the front and the brain from the front and below. The *spinal nerves* are named and numbered at the right. The twelve *cranial nerves*, not named, lie above the cervical and are so called because their roots lie within the cranium. The names of the segments of the sympathetic system (printed in heavy black) are designated at the left.

The brain and the spinal cord are both double organs, each side being fully equipped to take care of one side of the

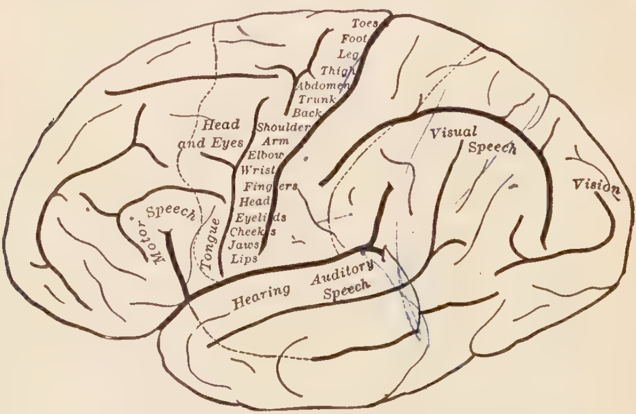


FIG. 43.—A localization of functions

body; but the two sides are harnessed together intimately for coöperation. The two halves of the brain are separated by the large *median fissure* shown slightly in Fig. 42, but clearly in Fig. 41, where it runs down to the *corpus callosum* (*CC*) which is made up of the commissural fibers.

The *localization of function* in the cortex of the brain is illustrated in the left-side view of the brain in Fig. 43, where certain *motor* and *sensory regions*, *areas*, and *centers* are designated. Thus, we speak of the motor region as lying along the large *central fissure*, and through this region there are areas assigned; *e.g.*, the lower extremities, the trunk, and the upper extremities. Within each area there are centers for specific muscles, such as a finger or an eyelid. The center marked "motor speech" is known as the *speech center*, which is usually better developed on the left side than on the right. These regions extend over into the cortex which folds into the median fissure.

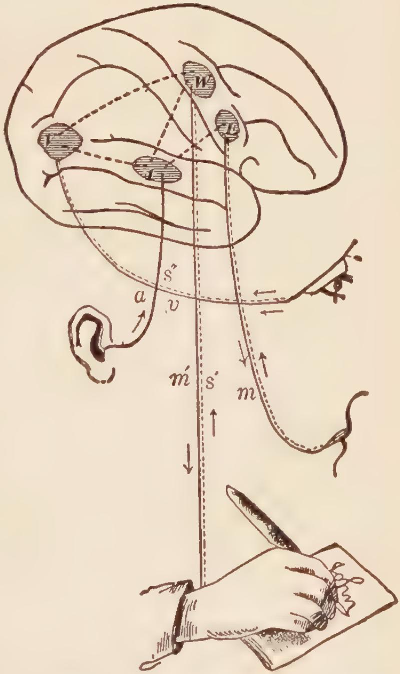


FIG. 44. — General scheme of the coöperation of brain centers

Fig. 44 is James' famous diagram to show the cortical

pathways involved when one speaks or writes in response to what is seen or heard. *A* is the auditory center, *V* the visual center, *W* the writing center, and *E* the center for speech.

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